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## Conference Paper

# Do Migrants React to Infrastructure Difference between Urban and Rural Areas?:Development and Application of an Extended Harris-Todaro Model

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Do Migrants React to Infrastructure Difference between  
Urban and Rural Areas?  
- Development and Application of an Extended Harris-Todaro Model

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**Abstract:**

Developing an extended model of the basic Harris-Todaro model of rural-urban migration, we analyze the effects of infrastructure availability together with the time-tested income effects whilst accommodating government behaviour through the provision and financing of infrastructure. Both the theoretical and empirical analyses confirm the assertion that infrastructure presence can be a force to reckon with as far as migration decisions are concerned. Comparison with the basic Harris-Todaro model also reveals that while the Todaro paradox is absent in the basic model, it can be present in the extended model.

**Keywords:** *Rural-urban migration, Infrastructure effects, Income difference, Equilibrium utility, Todaro-paradox.*

**JEL classification:** O17, O18, R23

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## **1. Introduction**

Rapid urbanization through migration in developing countries continues to engage the attention of both researchers and policy makers in recent times. This is due to the potential impact that migration can have on the overall economic development of a country as a whole. Regarding the rapidness of such urbanization, the World Bank<sup>1</sup> puts us in perspective by declaring that, about 90% of the world's population will be living in urban areas by the year 2025. For the developing world, urbanization which was just 18% in 1950, but neared 40% in 2000, is projected to be 54% in 2025. Whilst it can be argued that many developing countries still have capacity for agglomeration economies and therefore urbanization through migration may be good, it (urbanization) sometimes turns out to be a dilemma for policy makers as the benefits of urbanization is not appreciably accomplished. For example, a number of negative externalities such as unemployment, congestion and pollution have been cited as direct consequences of migration. In analyzing the underlying factors of rural to urban migration, economists have identified the difference between the income levels of urban and rural areas as the main driving force of migration. This school of thought has been in the limelight since the seminal works of Todaro (1969) and Harris and Todaro (1970). However, recent evidence shown by some studies (Yap (1976), Banerjee (1983), Jones and O'Neill (1995), Pham (2001), Barry (2002)) suggests that migration may be due to other factors of which inadequate or unavailability of infrastructure in the form of amenities at the sending region is one. For instance, Barry (2002) suggests that migration decisions may be based on the relative attractiveness of the receiving region in terms of the stock of infrastructure without giving adequate analysis of infrastructure effects. As seen in Table 1, electricity

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<sup>1</sup> World Bank Population Bulletin (2000).

accessibility is extraordinarily higher in the urban areas than in the rural areas in all the African countries shown. It can be said that this disparity occurs as a result of the pro-urban development stance taken by many governments which makes the urban areas more attractive to potential migrants due to better infrastructure.

**Table 1. Urban and Rural Access to Electricity in selected African countries**

| Country       | Percentage of Households Electrified |       |
|---------------|--------------------------------------|-------|
|               | Urban                                | Rural |
| Botswana      | 26.48                                | 2.09  |
| Cote d'Ivoire | 73.10                                | 12.70 |
| Ghana         | 61.70                                | 4.30  |
| Lesotho       | 14.00                                | 4.00  |
| Malawi        | 11.00                                | 0.32  |
| Mozambique    | 17.05                                | 0.66  |
| Namibia       | 26.00                                | 5.00  |
| South Africa  | 74.60                                | 27.20 |
| Swaziland     | 42.00                                | 2.00  |
| Tanzania      | 13.00                                | 1.00  |
| Zambia        | 18.85                                | 1.39  |
| Zimbabwe      | 64.72                                | 0.60  |

Source: World Bank, (ESMAP, 2000)

Jones and O'Neill (1995) also model a two-sector economy in which such population, taxation of both rural and urban sectors, rural transportation and infrastructure provision in the urban sector are identified as factors affecting deforestation in one way or the other. Using comparative static analysis, they concluded that increases in the urban infrastructure may reduce urban unemployment and expand manufacturing employment. Although they include infrastructure effects in the analysis, their recognition of infrastructure provision only in the urban area falls short of what generally prevails in many developing countries where there is dire need to provide infrastructure in the rural areas so as to decrease the disparity in development. Also, they consider personal income

tax as a source for infrastructure provision without stating how corporate tax is used in their model. Pham (2001) observes that utility difference between urban and rural areas causes migration and he concludes that wage equalization alone cannot explain such migration. He further argues that lack of certain goods and services in the form of infrastructure in rural areas and their presence in urban areas contribute to such migration trend. However, he did not give adequate analysis of infrastructure effects in his model. In a three sector study where the sectors are rural, urban modern and urban traditional sectors, Yap (1976) also studied about the effect of internal migration on economic growth of Brazil and concludes that indeed, rapid urban population growth has contributed positively to the growth and distribution of national product. Although she recognizes the effect of migration on government services, she considered only the urban infrastructure provision problem that results due to increasing urban population. Moreover, she gives no analysis of infrastructure effects in her model. In the case of Banerjee (1983), although he did not point out infrastructure difference as another reason for migration, he observes that there are other factors that can explain rural-urban migration since most people who migrate end up accepting incomes in the informal sector that are quite lower than agriculture income that can be obtained in the rural area <sup>2</sup>.

As can be seen in the above studies, although infrastructure is mentioned by most of the researchers, none of them analyzed the effects of infrastructure on rural-urban migration in more detail. In this paper, we provide a rigorous theoretical analysis of infrastructure effects on migration by providing an extended model of rural-urban migration based on

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<sup>2</sup> There are many other variants of the Harris-Todaro where infrastructure is not considered in the analysis. Among them are Brueckner (1990), Brueckner and Zenou (1999), Cole and Sanders (1985), Agesa (2001), Krichel and Levine (1999).

the seminal study by Harris and Todaro. We define infrastructure as the stock of government public investment in the area of electricity, water and sewerage, health facilities and education facilities and they are represented by the infrastructure stock which is a one dimensional variable measured by its value in monetary terms. In essence, infrastructure is thought to act as an augment to the production process as well as amenity for the households. For the analysis, we consider utility difference rather than income difference as the main cause of migration. It is noted that the utility level attainable in a particular area depends on the income as well as the amenity in the form of infrastructure that can be enjoyed. We also include government budget towards paying the interest cost of infrastructure provision and unemployment benefit and we avoid the problem of profits sharing by positing that government receives all corporate profits. Comparative static analysis is used to show the effects of various exogenous effects on the endogenous ones. Also, a comparison made with the basic Harris-Todaro model with infrastructure shows that the so called *Todaro paradox* is absent in the basic model while it can be present in the extended model. An empirical verification of the extended model is carried out using data on Ghana and the results support our assertion of infrastructure having a positive effect on migration. In fact, Ghana with its rapid urbanization rate, presents an excellent case for empirical study since it gives some evidence about some positive correlation between infrastructure and population densities. For instance, its urbanization witnessed increasing trend from 23% in 1960 through 32% in 1984 to 44% in 2000<sup>3</sup>, while infrastructure provisions continue to witness higher coverage in the urban areas than in rural areas as exhibited in Table 1.

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<sup>3</sup> Ghana population census reports, Statistical Service of Ghana.

The rest of the paper is organized as follows. Section 2 presents the model while the comparative static analysis is given in section 3. A comparison with the basic Harris-Todaro model is also made in this section. The empirical analysis based on the extended Harris Todaro model is then presented in section 4 and section 5 concludes.

## **2. Extended Model of Rural-Urban Migration**

Assume a developing country that has two distinct regions or areas called the rural and urban areas that differ mainly in terms of individual distributed incomes, total regional production as well as infrastructure level.<sup>4</sup> The movement of people through migration is seen as a response to the difference in utility levels determined by both wages and infrastructure levels representing amenities that prevails in these regions. In fact, infrastructure in stock serves not only as technological progress factor in production but also as amenity augmenting factor in people's lives.

### *2.1. The Rural Sector*

We assume that all able-bodied persons in a typical rural household engage themselves in the family's farming activity. Thus, labour force in the rural area is fully used. Therefore, it is justifiable to conclude that there is full employment in the rural area. Now, for the rural dwellers to engage in farming which is their productive activity, they have to combine inputs such as labour ( $L_a$ ), infrastructure<sup>5</sup> in terms of stock ( $G_a$ ) and fixed land ( $\bar{N}$ ) in the production process.<sup>6</sup> There is always the instance of population pressure for

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<sup>4</sup> The rural area is further identified with agriculture activity while the urban area is synonymous with production of manufacturing goods and services.

<sup>5</sup> Infrastructure here may include agriculture related ones like irrigation.

<sup>6</sup> The assumption of fixed land in the rural area is justified by the fact that each family has a defined area for farming.

land since family rather than individual ownership of land is common. In fact, this problem stems from the traditional land ownership structures in many African countries which are now seen as a stumbling block in realizing a viable modern land market. As noted by Goldsmith et al (2002) in their study about rural urban migration in Senegal, traditional agriculture in many developing countries is characterized by work sharing with quasi-unemployment and farm income sharing. The production process is labour intensive as existing infrastructure is inadequate to increase productivity. Also, the agriculture sector uses traditional means of production with the whole family providing labour and the farmer's household consumes significant portion of the produce. The rural production function is represented as

$$Y_a = Y_a(L_a, G_a; \bar{N}) \quad (1)$$

Since what is consumed by the family is not captured by the market, we assume that  $Y_a$  includes imputed value of agriculture products that are consumed by the family. The marginal products are given as  $Y_{aL} = \partial Y_a / \partial L_a > 0$ <sup>7</sup> and  $Y_{aG} = \partial Y_a / \partial G_a > 0$  for labour and infrastructure, respectively. Although the *marginal product* of labour determines the labour income in the urban sector, we use a definition involving *average product* of labour instead to determine the rural income. This is because payment systems in the agriculture sector are often based on income sharing rather than the marginal product.<sup>8</sup>

Thus, the per-capita agriculture income is given as

$$y_a = \frac{p_a Y_a(L_a, G_a; \bar{N})}{L_a} \quad (2)$$

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<sup>7</sup> This is thought to be relatively very low as compared to the urban wage.

<sup>8</sup> The income sharing system coupled with the family farming system may explain why visible unemployment is absent in the rural area. This can be referred to as the disguised unemployment.



where  $p_a$  is the agriculture output price.

This income is what an agriculture worker (for example, one family member) earns for engaging in agriculture activity and it may include imputed value of the agriculture consumption. Moreover, in the world of the original Harris-Todaro concept, it is this income that rural workers compare to the one they could obtain if they migrate to the cities before they decide to migrate or stay. Thus, one can say that rural-urban migration and agricultural performances are linked together through the value of agriculture income.

Following Harris-Todaro (1970), we define the agriculture output price  $p_a$  using the terms of trade between the rural and urban sectors as.

$$\frac{p_a}{p_m} = \gamma \left( \frac{Y_a}{Y_m} \right) \quad (3)$$

where  $p_m$  is the urban output price and  $\gamma$  is a function.

In this case, in the absence of international trade, it means that if more manufacturing goods are produced and substitution of agriculture output with manufacturing output takes place, agriculture output will be scarce and its price  $p_a$  will increase. By making the manufacturing price the numeraire, rural output price is represented as

$$p_a = \gamma \left( \frac{Y_a}{Y_m} \right), \quad \gamma' < 0 \quad (4)$$

Also consumption opportunity of composite good is represented by the size of disposable distributed income such that agriculture income  $y_a$  is equal to the amount or quantity of the composite good whose price is taken as unity. Infrastructure on the hand is provided

by the government and rural dwellers do not pay any taxes for it. Thus, if  $U_a$  is the utility enjoyed by a rural dweller, it can be represented as a function of a composite good, which is equal to the rural income, and the rural infrastructure  $G_a$  affecting amenity. This is given in equation form as

$$U_a = U(y_a, G_a) \quad (5)$$

Assuming additive separable function for the utility, (5) is stated as

$$U_a = W(y_a) + Z(G_a) \quad (6)$$

In this form,  $W$  is the utility derived from consumption while  $Z$  is the part depending on the infrastructure level as amenity<sup>9</sup>.

## 2.2. *The Urban Area*

The urban area is further categorized into two sub-sectors. These are the urban formal sector and the informal sector where the unemployed belong. We assume that people get employed only in the formal sector such that informal sector employs no workers in the model. One is therefore considered as unemployed if he is not in the formal sector.

### a) *The Urban Formal Sector*

The urban formal sector carries the onerous responsibility of production and is also the source of government revenue. It is noted that firms are the main engine of production and they carry out production with basic inputs which are labour, private capital  $\bar{K}_m$  and infrastructure. The last input is regarded as technical progress factor in the production

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<sup>9</sup> The use of such utility function implies that preferences are strongly separable. That is, a person's preferences about income may be independent of his preference about infrastructure in the form of amenities.

process. We assume that all the profits in the urban sector are collected by the government.<sup>10</sup> This simplification is to avoid modeling the investment behaviour of a firm (that is to close the system). The government in turn redistributes these profits to the economy through the provision of infrastructure and the payment of emoluments and benefits to the unemployed.<sup>11</sup> Thus, we avoid the problem of profit sharing by the firm. A macro production function of the urban formal sector is represented as

$$Y_m = Y_m(L_m, G_u, \bar{K}_m) \quad (7)$$

where  $L_m$  is the urban formal labour force,  $G_u$  the infrastructure input, and  $\bar{K}_m$  the private capital input which is made fixed.<sup>12</sup> The marginal products of labour and infrastructure are given as  $Y_{mL} = \partial Y_m / \partial L_m > 0$  and  $Y_{mG} = \partial Y_m / \partial G_u > 0$  respectively. It is also assumed that  $Y_{mLL} = \partial Y_{mL} / \partial L_m < 0$ ,  $Y_{mGG} = \partial Y_{mG} / \partial G_u < 0$  and  $Y_{mLG} = \partial Y_{mL} / \partial G_u > 0$ . Assuming further that the employment of labour force in the urban formal sector is determined such that the marginal product of labour is equal to the real wage rate,

$$y_m = Y_{mL}(L_m, G_u, \bar{K}_m) \quad (8)$$

where  $y_m$  is the urban formal wage and  $Y_m$  is evaluated in monetary terms since  $p_m$  is unity.

The utility level of a worker in the formal sector is evaluated as

$$U((1-t_L)y_m, G_u) = W((1-t_L)y_m) + Z(G_u) \quad (9)$$

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<sup>10</sup> Technically, this means that corporate profits are taxed at a 100% rate.

<sup>11</sup> This assumption can be compared to Brueckner and Zenou (1999) and Jones and O'Neill (1995) where the use of such profits is not clearly stated.

<sup>12</sup>  $\bar{K}_m$  plays a neutral role in the model. However, it is given here to show all the major inputs of production. Its subsequent exclusion from the model underpins the fact that in many development countries, public capital takes a larger share of the total capital in the country.

where  $W((1-t_L)\bar{w})$  is the portion of the expected utility attributable to income, and  $Z$  the part for infrastructure level as amenity and  $t_L$  is the tax rate. Although  $y_m$  is the prevailing income in the urban formal sector, we further assume that there is a minimum wage  $\bar{w}$  fixed by legislation such that the minimum wage is above the market clearing wage  $y_m$ <sup>13</sup>. Under this circumstance, unemployment is bound to set in since at such a high wage, firms will have to decrease their labour size. Thus, in the special case where the urban wage is equal to the minimum wage, workers receive  $\bar{w}$  such that (8) can be rewritten as

$$\bar{w} = Y_{mL}(L_m, G_u, \bar{K}_m) \quad (10)$$

*b) Labour Market and the Unemployed Informal Sector*

It is assumed that the country has a labour population of size  $L$  and this is shared among the rural, urban formal and the unemployed as  $\bar{L}_a$ ,  $\bar{L}_m$  and  $\bar{L}_i$ , respectively. Now, when migration takes place, it redistributes the total labour population such that

$$L_a + L_m + L_i = \bar{L}_a + \bar{L}_m + \bar{L}_i = L \quad (11)$$

where  $L_a$ ,  $L_m$  and  $L_i$  are the new labour population sizes for the respective groups.

If the probability of being unemployed in the urban sector is  $\pi$ , then

$$\pi = \frac{L_i}{L_m + L_i} \quad (12)$$

Thus, the chance of being employed in the urban formal sector is given as

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<sup>13</sup> In developing countries, it is possible that the market clearing wage is sometimes lower than the minimum wage necessary to sustain a worker. The setting up of the minimum wage is therefore to protect workers interest and to ensure productivity.

$$1 - \pi = \frac{L_m}{L_m + L_i} \quad (13)$$

For the unemployed informal sector, we assume that it is dormant as far as production is concerned. Its inclusion in the model is to help us assess the impact of government unemployment benefits that are paid to the unemployed. In fact, it can be said that associating the informal sector with the unemployed can be justifiably close to reality in many developing countries. Firstly, many people in the informal sector consider themselves as unemployed as far as employment status is concerned. In their view, it is only when one gets a job in the formal sector that one can regard himself as working. Moreover, it is always difficult for governments in developing countries to estimate the incomes of those in the informal sector. It goes without saying that data on activities of the informal sector are non-existent in many developing countries. However, it must be noted that by lumping those in the informal and the unemployed together, we assume that they all receive some form of unemployment benefits from the government in order to survive. We represent this form of income transfer to an unemployed person as  $y_i$ , so that total government expenditure for unemployment benefits is  $y_i$  times unemployed population, that is  $L_i y_i$ . Even though they do not get jobs, the unemployed can enjoy the urban amenity in from  $G_u$  as far as they reside in cities. Using additive separable function as in the case of rural utility, the utility level of an unemployed person in the urban area is thus,

$$U(y_i, G_u) = W(y_i) + Z(G_u) \quad (14)$$

naturally, the urban sector's expected utility is given as

$$\begin{aligned}
E(U_u) &= (1 - \pi)U([1 - t_L]y_m, G_u) + \pi U(y_i, G_u) \\
&= (1 - \pi)W_1([1 - t_L]y_m) + \pi W_2(y_i) + Z(G_u)
\end{aligned} \tag{15}$$

In terms of the institutionally fixed wage, the above specification is reduced to

$$E(U_u) = EU([1 - t_L]\bar{w}, y_i, G_u) = (1 - \pi)W((1 - t_L)\bar{w}) + \pi W(y_i) + Z(G_u) \tag{16}$$

Thus, even if people are likely to be unemployed, they are still induced to migrate due to presence of infrastructure in the form of better amenity in the urban area.

### *c) Government Role in the Model*

Our reasoning concerning infrastructure has been that it is capable of affecting migration decisions just like the wage effect. Its provision is therefore of utmost importance in helping to distribute population. Principally, the government is the sole provider of both rural and urban infrastructure which together constitutes the overall infrastructure  $G = G_a + G_u$ . Additionally, the government has to cater for the unemployed by paying some form of unemployment benefits to them. However, the investment in infrastructure and unemployment payments have to be funded mainly through taxes which depend directly on the size of the population forming the tax base and on the amount of taxable corporate income. Thus in this setting, the possibility of deficit financing is excluded.<sup>14</sup> However, it is pertinent to note that these arduous tasks by the government are affected by the level of urbanization in the country. In particular, increase in urban population and concentration of economic activities in urban areas creates pressures to expand urban infrastructure much more than in the rural areas. For the

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<sup>14</sup> Although this is likely in developing countries, the model envisages a developing country where reliance on deficit financing is kept to the minimum.

purpose of taxation, we assume that the main tax base for the government is the urban formal sector where individuals pay personal income taxes and as explained earlier, firms are technically, taxed at 100%. Products from the rural sector are non-taxable to reflect the low income levels in that sector. Thus, total tax revenue  $T$  is given by

$$T = t_L L_m y_m + (Y_m - L_m y_m) \quad (17)$$

This is, the total revenue that the government uses to invest in both rural and urban infrastructure as well as payments to the unemployed in the form of unemployment benefits. It may be recalled that the urban output price  $p_m$  is made the numeraire so it doesn't appear in (17). Thus, assuming that the government uses taxes to pay the current cost of infrastructure and the payment of unemployment benefits, the total government expenditure  $E$  is given by the following equation

$$E = r(G_a + G_u) + L_i y_i, \quad (18)$$

where  $r > 0$  is the interest rate.

It is assumed that total cost for providing infrastructure  $G$  is financed from outside sources and the government continues to pay the annual cost which is the interest cost  $r$ .<sup>15</sup> Equations (17) and (18) represent the government's budget constraint as far as the provision of infrastructure and subsidies to the unemployed are concerned. Additionally, it is worthy to note from these two equations that the government also faces with the task of distributing tax revenue between infrastructure expenditure and unemployment expenditure. For instance, if government expenditure cannot be increased due to fixed revenue, any increase in the unemployed number through migration would raise the total

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<sup>15</sup> This seems to be the case in many developing countries where interests on outside loans contracted for development continue to be paid whilst the actual loan payment may never start, hence the huge indebtedness saddling developing countries.

unemployment benefit such that infrastructure expenditure is reduced. Conversely, if the government is pro-infrastructure, then it means unemployment expenditure has to be cut down even if the number of unemployed is increasing.<sup>16</sup> Such an approach is likely to breed other negative externalities in the society like robbery due to poverty. It is therefore important for the government to be able to apportion expenditure to infrastructure financing and the care of the unemployed in a more judicious manner. Now for a balanced government budget,  $T = E$  such that using the minimum wage, we can write

$$t_L L_m \bar{w} + (Y_m - L_m \bar{w}) = r(G_a + G_u) + L_i y_i, \quad (19)$$

So far the model has identified activities in the rural area, the urban area, and the interaction of government in the economy through the provision of infrastructure and the payment of unemployed income to the unemployed. It is evident from above that the actors in the economy are rural workers, urban employees, firms, the unemployed and the government.

*d) The Migration Condition*

We now turn our attention to conditions under which migration will either continue or is expected to cease. We have so far identified a utility that can be enjoyed in the rural area as  $U_a$  from equation (6). The expected urban utility is also given as  $E(U_u)$  as per equation (16). Essentially, a potential migrant in the rural area compares rural utility  $U_a$  to expected urban utility  $E(U_u)$  and when  $E(U_u) > U_a$ , he decides to migrate. Therefore, migration is likely to stop at the equilibrium when

$$E(U_u) = U_a \quad (20)$$

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<sup>16</sup> It is pertinent to note that if revenue has to increase then, the tax rate must increase.



Denoting the equilibrium utility by  $V$ , it is seen that,

$$V = E(U_u) = U_a \quad (21)$$

That is,

$$V = U_a = W(y_a) + Z(G_a) \quad (22)$$

$$V = E(U_u) = (1 - \pi)W([1 - t_L]\bar{w}) + \pi W(y_i) + Z(G_u) \quad (23)$$

Under minimum wage regime, equations (22) and (23) determine the migration equilibrium. It must be mentioned that the equilibrium utility can fluctuate due to migration. Thus, it is the duty of the government to ensure the maximization of the equilibrium utility of all citizens through the implementation of sound policies aimed at improving the lot of its citizens. The effect of government policy variable such as infrastructure levels or the minimum wage on say, the urban population size or agriculture income is therefore of utmost importance. As stated elsewhere in the model building, although migration decisions are made by individuals, its cumulative nature calls for national concern. This is because it is capable of altering the distribution of the national population and hence, affecting government spending. Thus, the inter-relationship among migration, infrastructure, outputs and the labour market calls for a joint or simultaneous approach to determine certain characteristics of the model. We use a comparative static analysis to determine the exogenous effects in the model and this is discussed in the next section.

### 3. Comparative Static Analyses

For identification purposes, it is expedient at this point to discuss some characteristics about the variables that may justify their categorization. For the exogenous variables, we

first consider the infrastructure level in each area. Since it is the government that provides infrastructure, we treat infrastructure as policy variables and our interest is in how it alters for example, the labour distribution and for that matter, the population distribution of the country as a whole. Additionally, the levels in infrastructure are expected to affect incomes and output prices as well. This is because it acts as an input in the production process of both rural and urban areas. Perhaps, the most important finding will be how infrastructure affects unemployment rate and the personal income tax rate. Infrastructure effects on unemployment rate is expected to directly give some measure of the existence or absence of the so called *Todaro-paradox* which states that any effort by the government to create jobs in order to reduce urban unemployment ends up triggering more in-migration to the city. In addition to infrastructure, the minimum wage and unemployed benefits are also used as exogenous variables to reflect the fact that their values are given by the government legislation.<sup>17</sup> The total population size is also treated as given at any point in time while interest rate is also considered as exogenous. The exogenous variables are therefore given as  $G_a, G_u, \bar{w}, y_i, r$  and  $L$ . On the other hand, the endogenous ones are  $L_a, L_m, L_i, p_a, y_a, t_L, \pi$  and  $V$ . These are the variables whose behaviour can be predicted by this model. Equations (2), (4), (10), (11), (12), (19), (22) and (23) are identified as a system of eight equations in the endogenous variables which can be solved as functions of the exogenous variables. This is done by solving for total differentials with respect to the exogenous variables at equilibrium. The matrixes table in (24) shows the model in total differential form while the signs of the coefficients in the

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<sup>17</sup> In fact, this is the case in many developing countries where centralized governments exist and they determine the amount of say the minimum wage or the unemployment benefit without due regard to market forces.

matrix are given in the Appendix. Assumptions about the signs of the first and second order derivatives of outputs and utilities are also given there. Using the matrix, the effects of all the exogenous variables can be determined. We show below, the methodology to derive the effects of only the urban infrastructure variable.<sup>18</sup>

### 3.1. Determination of Effects of Urban infrastructure $G_u$

As was pointed out in the introduction, the pro-urban stance of many governments in developing countries raises questions about how such policy direction can benefit the whole country in general. Additionally, it is noted that the consideration of infrastructure as affecting migration constitutes a primary premise of this study.

$$\begin{aligned}
& \begin{bmatrix} \frac{p_a(L_a Y_{aL} - Y_a)}{L^2} & 0 & 0 & -\frac{Y_a}{L_a} & 1 & 0 & 0 & 0 \\ -\gamma_k \frac{Y_{aL}}{Y_m} & \gamma_k \frac{Y_a Y_{mL}}{Y_m^2} & 0 & 1 & 0 & 0 & 0 & 0 \\ 0 & -Y_{mLL} & 0 & 0 & 0 & 0 & 0 & 0 \\ 1 & 1 & 1 & 0 & 0 & 0 & 0 & 0 \\ 0 & [Y_{mL} - (1-t_L)\bar{w}] & -y_i & 0 & 0 & L_m \bar{w} & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & (1-\pi)W_{y_m} \bar{w} \{W((1-t_L)\bar{w}) - W(y_i)\} & 1 & 0 \\ 0 & \frac{L_i}{(L_m + L_i)^2} & -\frac{L_m}{(L_m + L_i)^2} & 0 & 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 0 & -W_{y_a} & 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} dL_a \\ dL_m \\ dL_i \\ dp_a \\ dy_a \\ dt_L \\ d\pi \\ dV \end{bmatrix} \\
& = \begin{bmatrix} \frac{p_a Y_{aG}}{L_a} \\ \gamma_k \frac{Y_{aG}}{Y_m} \\ 0 \\ 0 \\ r \\ 0 \\ 0 \\ Z_{G_u} \end{bmatrix} dG_a + \begin{bmatrix} 0 \\ -\gamma_k \frac{Y_a Y_{mG}}{Y_m^2} \\ Y_{mLG} \\ 0 \\ (r - Y_{mG}) \\ Z_{G_u} \\ 0 \\ 0 \end{bmatrix} dG_u + \begin{bmatrix} 0 \\ 0 \\ -1 \\ 0 \\ (1-t_L)L_m \\ (1-\pi)(1-t_L)W_{y_m} \\ 0 \\ 0 \end{bmatrix} d\bar{w} + \begin{bmatrix} 0 \\ 0 \\ 0 \\ 0 \\ L_i \\ \pi W_{y_i} \\ 0 \\ 0 \end{bmatrix} dy_i + \begin{bmatrix} 0 \\ 0 \\ 0 \\ 1 \\ 0 \\ 0 \\ 0 \\ 0 \end{bmatrix} dL + \begin{bmatrix} 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \end{bmatrix} dG_u + G_u dr \tag{24}
\end{aligned}$$

With the other exogenous variables being held constant, the total effect of  $G_u$  are

<sup>18</sup> Analysis of the other exogenous effects can be made in a similar way and the detailed process of derivation is available upon request from the authors.

obtained from (24) and represented by the following equations:

$$-\frac{p_a(L_a Y_{aL} - Y_a)}{L^2} \frac{dL_a}{dG_u} - \frac{Y_a}{L_a} \frac{dp_a}{dG_u} + \frac{dy_a}{dG_u} = 0 \quad (25)$$

$$-\gamma_k \frac{Y_{aL}}{Y_m} \frac{dL_a}{dG_u} + \gamma_k \frac{Y_a Y_{mL}}{Y_m^2} \frac{dL_m}{dG_u} + \frac{dp_a}{dG_u} = -\gamma_k \frac{Y_a Y_{mG}}{Y_m^2} \quad (26)$$

$$-Y_{mLL} \frac{dL_m}{dG_u} = Y_{mLG} \quad (27)$$

$$\frac{dL_a}{dG_u} + \frac{dL_m}{dG_u} + \frac{dL_i}{dG_u} = 0 \quad (28)$$

$$[Y_{mL} - (1-t_L)\bar{w}] \frac{dL_m}{dG_u} - y_i \frac{dL_i}{dG_u} + L_m \bar{w} \frac{dt_L}{dG_u} = r - Y_{mG_u} \quad (29)$$

$$(1-\pi)W_{y_m} \bar{w} \frac{dt_L}{dG_u} + \{W((1-t_L)\bar{w}) - W(y_i)\} \frac{d\pi}{dG_u} + \frac{dV}{dG_u} = Z_{G_u} \quad (30)$$

$$\frac{L_i}{(L_m + L_i)^2} \frac{dL_m}{dG_u} - \frac{L_m}{(L_m + L_i)^2} \frac{dL_i}{dG_u} + \frac{d\pi}{dG_u} = 0 \quad (31)$$

$$-W_{y_a} \frac{dy_a}{dG_u} + \frac{dV}{dG_u} = 0 \quad (32)$$

Since  $-Y_{mLL} > 0$ , and  $Y_{mLG} > 0$ ,  $dL_m/dG_u > 0$  is concluded in (27). That is, formal urban labour is bound to increase when urban infrastructure stock increases. However, we are interested in the behaviour of the equilibrium utility whenever there is an increase in the urban infrastructure stock. There is a strong belief that the equilibrium utility will improve if infrastructure increases. That is,  $dV/dG_u > 0$ . Nevertheless, it suffices that we prove this rigorously. First, we suppose that the effect of urban infrastructure on utility is negative such that  $dV/dG_u < 0$ . By the assumption of  $W_{y_a} > 0$ , it can be seen that, for (32) to hold, it must be that  $dy_a/dG_u < 0$ .

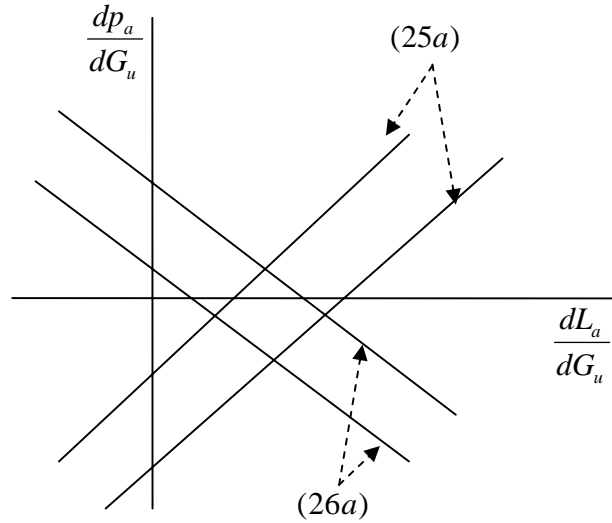
Next, we investigate the effect of urban infrastructure on the agriculture price and agriculture labour. From equation (26),

$$\frac{dp_a}{dG_u} = \gamma_k \frac{Y_{aL}}{Y_m} \frac{dL_a}{dG_u} - \gamma_k \frac{Y_a Y_{mL}}{Y_m^2} \frac{dL_m}{dG_u} - \gamma_k \frac{Y_a Y_{mG}}{Y_m^2} \quad (26a)$$

Also from equation (25),

$$\frac{dp_a}{dG_u} = -\frac{1}{(Y_a/L_a)} \frac{p_a(L_a Y_{aL} - Y_a)}{L^2} \frac{dL_a}{dG_u} + \frac{1}{(Y_a/L_a)} \frac{dy_a}{dG_u} \quad (25a)$$

These are two equations in two unknowns which are  $dp_a/dG_u$  and  $dL_a/dG_u$ . Graphically, they can be represented as shown in Figure 1 below. Using the assumptions that  $Y_{aL} > 0$  and  $\gamma_k < 0$ , it can be deduced from the figure that  $dL_a/dG_u$  is always positive whilst  $dp_a/dG_u$  can be positive or negative depending on the value of either of the intercepts.



**Figure 1. Graph of  $dp_a/dG_u$  against  $dL_a/dG_u$**

In particular, if (25a) intercept is largely negative or if (26a) intercept is very small,

$dp_a/dG_u < 0$ . Now where  $dL_a/dG_u > 0$ , we can deduce from (28) that  $dL_i/dG_u < 0$ .

Once this is true, it is seen from (31) that,  $\frac{d\pi}{dG_u} = \frac{L_m}{(L_m + L_i)^2} \frac{dL_i}{dG_u} - \frac{L_i}{(L_m + L_i)^2} \frac{dL_m}{dG_u}$  is

necessarily less than zero since  $dL_m/dG_u$  is positive by assumption. That is,  $d\pi/dG_u < 0$  implying unemployment rate decreases as infrastructure improves. Now from (29), since the first two terms are positive by virtue of the signs of  $dL_m/dG_u$  and  $dL_i/dG_u$ , the last term must be negative to satisfy the negative sign of the right hand side term. This implies that the effect of infrastructure on tax rate  $dt_L/dG_u$ , is negative. However, from

$$(30), \frac{dV}{dG_u} = -(1-\pi)W_{y_m} \bar{w} \frac{dt_L}{dG_u} - \{W((1-t_L)\bar{w}) - W(y_i)\} \frac{d\pi}{dG_u} + Z_{G_u}. \text{ Using the results of}$$

$d\pi/dG_u < 0$  and  $dt_L/dG_u < 0$  in addition to the fact that  $Z_{G_u} > 0$ , we notice that all the terms on the right hand side of the equation above are positive.<sup>19</sup> This implies  $dV/dG_u > 0$ . But this is clearly a contradiction to our earlier assumption that  $dV/dG_u < 0$ . Therefore it must be that  $dV/dG_u > 0$  which will imply  $dy_a/dG_u > 0$  from (32). Up to this point, we have shown that,  $dL_m/dG_u > 0$ ,  $dV/dG_u > 0$  and  $dy_a/dG_u > 0$ . We now investigate again the signs of  $dt_L/dG_u$ ,  $d\pi/dG_u$ ,  $dL_i/dG_u$ ,  $dL_a/dG_u$  and  $dp_a/dG_u$ .

*Investigating the signs of  $dL_i/dG_u$ ,  $dt_L/dG_u$  and  $d\pi/dG_u$*

$$\text{From (29), } \frac{dL_i}{dG_u} = \frac{L_m \bar{w}}{y_i} \frac{dt_L}{dG_u} + \frac{[Y_{mL} - (1-t_L)\bar{w}]}{y_i} \frac{dL_m}{dG_u} - \frac{(r - Y_{mG})}{y_i} \quad (29a)$$

We also deduce from (31) that,

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<sup>19</sup>  $W((1-t_L)\bar{w}) > W(y_i)$  must hold otherwise people may choose not to work if the unemployment benefit is larger than the urban net income.

$$\frac{d\pi}{dG_u} = \frac{L_m}{(L_m + L_i)^2} \frac{dL_i}{dG_u} - \frac{L_i}{(L_m + L_i)^2} \frac{dL_m}{dG_u} \quad (31a)$$

Substituting this into (30), we get

$$(1-\pi)W_{y_m} \bar{w} \frac{dt_L}{dG_u} + \{W((1-t_L)\bar{w}) - W(y_i)\} \left[ \frac{L_m}{(L_m + L_i)^2} \frac{dL_i}{dG_u} - \frac{L_i}{(L_m + L_i)^2} \frac{dL_m}{dG_u} \right] + \frac{dV}{dG_u} = Z_{G_u}$$

which can be re-arranged as

$$\begin{aligned} \{W((1-t_L)\bar{w}) - W(y_i)\} \left( \frac{L_m}{(L_m + L_i)^2} \right) \frac{dL_i}{dG_u} &= -(1-\pi)W_{y_m} \bar{w} \frac{dt_L}{dG_u} \\ &+ \{W((1-t_L)\bar{w}) - W(y_i)\} \left( \frac{L_i}{(L_m + L_i)^2} \right) \frac{dL_m}{dG_u} - \frac{dV}{dG_u} + Z_{G_u} \end{aligned}$$

This implies

$$\begin{aligned} \frac{dL_i}{dG_u} &= - \frac{(1-\pi)W_{y_m} \bar{w}}{\{W((1-t_L)\bar{w}) - W(y_i)\} \left[ L_m / (L_m + L_i)^2 \right]} \frac{dt_L}{dG_u} \\ &+ \frac{\{W((1-t_L)\bar{w}) - W(y_i)\} \left[ L_i / (L_m + L_i)^2 \right] \frac{dL_m}{dG_u} - \frac{dV}{dG_u} + Z_{G_u}}{\{W((1-t_L)\bar{w}) - W(y_i)\} \left[ L_m / (L_m + L_i)^2 \right]} \end{aligned} \quad (30a)$$

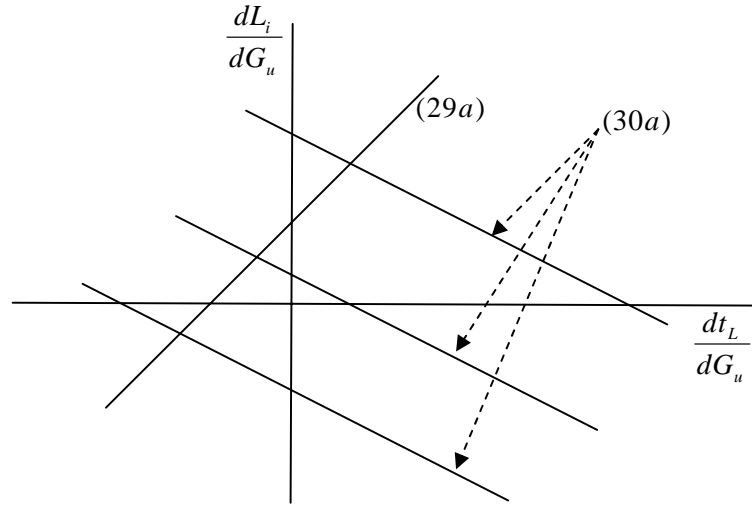
(29a) and (30a) are two equations in  $dL_i/dG_u$  and  $dt_L/dG_u$  which are shown in Figure 2.

*Case (1):* When  $dt_L/dG_u > 0$  and  $dL_i/dG_u > 0$ .

This occurs in the first quadrant when an increase in the tax rate due to a rise in infrastructure also has the tendency to cause the number of the unemployed to increase.

If this happens, then from (28),  $dL_u/dG_u < 0$ . Indeed, this is to be expected since many people who make up the unemployed might have migrated from the rural area. We also realize from (30) that when  $dt_L/dG_u > 0$  and the change in urban utility due to urban

infrastructure  $Z_{G_u}$  is large,  $d\pi/dG_u > 0$ . Even though tax increase reduces the urban utility level, many people migrate to cities because of large amenity augmentation effect.



**Figure 2. Graph of  $dL_i/dG_u > 0$  against  $dt_L/dG_u > 0$**

As a result, the unemployment rate is increased. On the other hand, it is possible to have a situation under which  $d\pi/dG_u < 0$ . This occurs when  $Z_{G_u}$  is very small. In this situation, the change in equilibrium utility due to urban infrastructure is small enough to make migration an undesirable activity. Additionally, such a situation can occur when a large portion of improvements in urban infrastructure go in to increase productivity. Firms will then demand more labour thus, decreasing the unemployment rate.

*Case (2): When  $dt_L/dG_u < 0$  and  $dL_i/dG_u > 0$ .*

This occurs in the second quadrant when (30a) intercept is very small (near zero) and  $dL_a/dG_u < 0$  still holds. From (30), it is noted that the sign of  $d\pi/dG_u$  can be negative when a change in equilibrium utility due to urban infrastructure  $dV/dG_u$ , is very large.



This indicates that if equilibrium utility improvement is largely attributed to infrastructure, then an increase in infrastructure would not cause more unemployment as is envisaged in the Todaro paradox where  $d\pi/dG_u > 0$ .<sup>20</sup> However,  $d\pi/dG_u$  is positive when  $dV/dG_u$  is small.

*Case (3): When  $dt_L/dG_u < 0$  and  $dL_i/dG_u < 0$*

This occurs in the third quadrant when the intercept of (30a) is negatively large.

That is,

$$\frac{\{W((1-t_L)\bar{w}) - W(y_i)\} \left[ \frac{L_i}{(L_m + L_i)^2} \right] \frac{dL_m}{dG_u} - \frac{dV}{dG_u} + Z_{G_u}}{\{W((1-t_L)\bar{w}) - W(y_i)\} \left[ \frac{L_m}{(L_m + L_i)^2} \right]} \square 0$$

Now, when  $dL_i/dG_u < 0$ , it is seen from (31) that  $d\pi/dG_u < 0$ . We explain the above situation as follows. The tax rate doesn't increase as a result of increase in urban infrastructure, since formal employment tends to increase, which leads to a decrease in the unemployed and hence a decline in the unemployment rate.

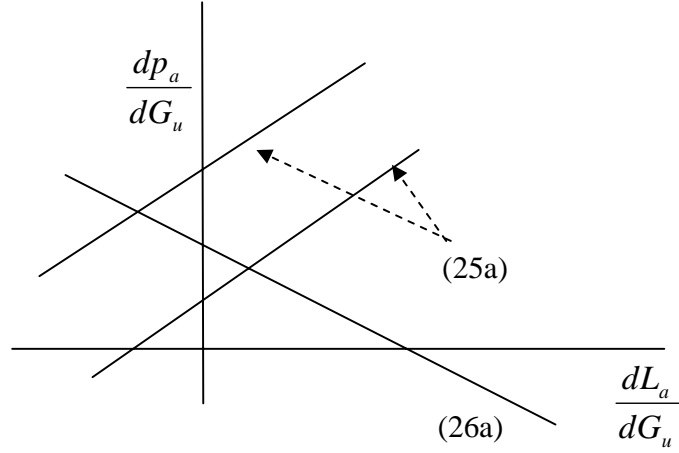
*Investigating the signs of  $dp_a/dG_u$  and  $dL_a/dG_u$*

Using the results of  $dV/dG_u > 0$ ,  $dL_m/dG_u > 0$  and  $dy_a/dG_u > 0$  obtained earlier on, a new figure (Figure 3) can be drawn where the intercept of (25a) becomes positive while the slope is still positive. However, (26a) is the same as shown in the Figure 1. Thus,

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<sup>20</sup>The reduction in the tax rate in the event of increasing infrastructure can be possible when the tax base is enlarged. This means more people will be employed so that total revenue will offset the loss due to reduction in the tax rate.

$dp_a/dG_u$  is always positive whilst  $dL_a/dG_u$  can be positive or negative depending on the value of intercept in (25a).



**Figure 3. Graph of  $dp_a/dG_u$  against  $dL_a/dG_u$**

In particular,  $dL_a/dG_u$  is positive when  $\frac{1}{(Y_a/L_a)} \frac{dy_a}{dG_u} > -\gamma_k \frac{Y_a Y_{mL}}{Y_m^2} \frac{dL_m}{dG_u} - \gamma_k \frac{Y_a Y_{mG}}{Y_m^2}$ .

Otherwise, it is negative. The effects of the other exogenous variables are similarly derived and we summarize the results in Table 2.<sup>21</sup>

### 3.2. Discussion of other Results

Table 2 reveals certain interesting characteristics of the exogenous effects. The rural infrastructure has unambiguous negative effect on the agriculture price whilst it has no effect on the urban formal labour.

<sup>21</sup> It might be argued that urban infrastructure should be increased indefinitely since  $dV/dG_u$  is certainly positive. However, it is recalled that the result of  $dV/dG_u > 0$  depends on the assumption that  $Y_{mG} > r$ . Since it is natural that  $Y_{mGG} < 0$ ,  $Y_{mG}$  is necessarily reduced below  $r$  as  $G_u$  increases beyond a certain level, whereby the right-hand side of (29) becomes positive. Thus, for large  $G_u$ , it follows that  $dV/dG_u < 0$ .

**Table 2. Summary of Comparative Static Analysis for Extended Model**

| Effect on \ Increase in | $dG_a$ | $dG_u$ | $d\bar{w}$ | $dy_i$ | $dL$ | $dr$ |
|-------------------------|--------|--------|------------|--------|------|------|
| $dL_a$                  | $\pm$  | $\pm$  | $\pm$      | $\pm$  | +    | +    |
| $dL_m$                  | 0      | +      | -          | 0      | 0    | 0    |
| $dL_i$                  | $\pm$  | $\pm$  | $\pm$      | $\pm$  | +    | -    |
| $dp_a$                  | -      | +      | $\pm$      | $\pm$  | -    | -    |
| $dy_a$                  | $\pm$  | +      | $\pm$      | $\pm$  | -    | -    |
| $dt_L$                  | $\pm$  | $\pm$  | $\pm$      | +      | +    | +    |
| $d\pi$                  | $\pm$  | $\pm$  | $\pm$      | $\pm$  | +    | -    |
| $dV$                    | $\pm$  | +      | $\pm$      | $\pm$  | -    | -    |
| $dL_u = dL_m + dL_i$    | $\pm$  | $\pm$  | $\pm$      | $\pm$  | +    | -    |

However, its effects on the other variables are indeterminate. In particular, while an increase in urban infrastructure unambiguously increases equilibrium utility, increase in rural infrastructure can either have positive or negative effect on the equilibrium utility. The effect is positive if agriculture income increases as a result of improvement in rural infrastructure. Otherwise, the effect is negative. Although the effect on unemployment rate is expected to be negative since it is an improvement in rural infrastructure ought to open up job avenues in the rural area, this effect can also be positive if rural infrastructure so provided, rather goes in to improve the technology such that there will be a kind of substitution of labour with capital.

For, the minimum wage effects, except that for urban formal labour which is negative, the rest are indeterminate. It is deduced that if it is possible to increase the equilibrium utility by an increase in the minimum wage, then we expect agriculture income to also increase with the minimum wage increase. This implies that when minimum wage increases, many people from the rural area respond by migrating to the cities which tends

to increase agriculture income. In the urban areas, the increase in minimum wage causes firms to shrink their labour size. It is therefore natural that unemployment rate increases, first from the reduction in urban formal labour size and secondly, from migrants who respond to such increase in the minimum wage. The effect of minimum wage on equilibrium utility can also be negative and this occurs when the effect of increasing the minimum wage greatly induces layoffs and high unemployment rate. In this situation, firms will be able to hire only a handful of employees. For the unemployment benefit, all the effects are indeterminate except that for the tax rate which is positive. This underscores the importance of tax in the economy if government is welfare oriented. The effect of total labour force is seen as lowering equilibrium utility whilst it increases unemployment rate. The interest rate payable on infrastructure loans is also seen to have a negative effect on the equilibrium utility. This is due to the fact high interest rate may compel governments to raise the tax rate since the interest payments will be too high to sustain development plans of the country.

### 3.3. Comparison with the Basic Harris-Todaro Model

Before we test the model empirically, it is beneficial to make some comparisons with the basic Harris-Todaro model where infrastructure is explicitly included as input into production but not as amenity. Essentially, this basic model can be represented by the following five equations.

$$\bar{w} = Y_{mL}(L_m, G_u) \quad (33)$$

$$y_a = p_a \frac{Y_a(L_a, G_a)}{L_a} \quad (34)$$

$$(1 - \pi)\bar{w} + \pi y_i = y_a \quad (35)$$

$$p_a = \gamma \left( \frac{Y_a(L_a, G_a)}{Y_m(L_m, G_u)} \right), \quad \gamma' < 0 \quad (36)$$

$$L_a + \frac{L_m}{(1-\pi)} = L \quad (37)$$

where the notations are interpreted as before. Equation (33) is the urban formal wage which is set at the minimum wage level  $\bar{w}$  while (34) is the agriculture wage. The next equation gives the condition for equilibrium in migration to occur. This is when the expected urban wage is equal to the agriculture wage. In the absence of international trade, the agriculture output price  $p_a$  is defined as the relative outputs of rural and urban areas and this is given by equation (36). Equation (37) is the distribution of total labour  $L$  into agriculture labour  $L_a$  and urban formal labour  $L_m$ . By similar derivation as in the extended model, the effects of the exogenous variables  $G_u, G_a, \bar{w}, y_i$  and  $L$  on the endogenous ones represented by  $L_m, L_a, p_a, y_a$  and  $\pi$  are determined. The results obtained are summarized in Table 3 below and we compare them with the results obtained in the extended model in Table 2.

**Table 3. Summary of Comparative Static Analysis for the Basic Model**

| Effect on | Increase in | $dG_a$ | $dG_u$ | $d\bar{w}$ | $dy_i$ | $dL$ |
|-----------|-------------|--------|--------|------------|--------|------|
| $dL_a$    | $\pm$       | $\pm$  | $\pm$  | $\pm$      | $-$    | $+$  |
| $dL_m$    | $0$         | $0$    | $+$    | $-$        | $0$    | $0$  |
| $dp_a$    | $-$         | $-$    | $+$    | $\pm$      | $+$    | $-$  |
| $dy_a$    | $\pm$       | $\pm$  | $+$    | $\pm$      | $+$    | $-$  |
| $d\pi$    | $\pm$       | $\pm$  | $-$    | $\pm$      | $+$    | $+$  |

It is noted that almost the same results apply between the two models. The significant difference occurs in the case of the effect of  $y_i$ . In particular, whereas in the basic model, an increase in  $y_i$  necessarily increases welfare in terms of the expected income (measured by  $y_a$ ), in the extended model, it does not necessarily increase the welfare in terms of utility. This is because, in the basic model, an increase in  $y_i$  occurs not through any additional burden on the residents while this is the case in the extended model where an increase in tax payment is accompanied.

Furthermore, it is noted that an increase in  $G_u$  necessarily increases the welfare of people in both models. On the other hand, increase in  $G_a$  does not necessarily improve the welfare in either model. This is because under the minimum wage scheme,  $L_m$  is not increased with and there is a possibility that  $y_a$  also decreases. The basic model also shows that, when  $G_u$  is increased so as to increase employment, the *Todaro paradox* ( $d\pi/dG_u > 0$ ) never occurs.<sup>22</sup> However, in the extended model where urban infrastructure serves not only as technological progress factor but as amenity; increased  $G_u$  attracts more people from the rural area. This occurs even though some of them cannot find jobs in the urban area thus resulting in higher unemployment rate. In the case of the effect of minimum wage increase, it is noted that the effects are the same in most of the cases. However, when  $\left| \frac{dL_m}{d\bar{w}} \right|$  is small, it is likely that  $\frac{dp_a}{d\bar{w}} > 0$ ,  $\frac{dL_a}{d\bar{w}} < 0$ , and

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<sup>22</sup> Brueckner and Zenou (1999) also find the absence of the Todaro paradox in their extended Harris-Todaro model which includes the effect of urban land market. However, it is noted that the paradox *may* be present in their model if rental revenue is redistributed by the government to the people.

$\frac{d\pi}{d\bar{w}} > 0$ , but  $\frac{dy_a}{d\bar{w}} > 0$  and the welfare is increased. Conversely, when  $\left| \frac{dL_m}{d\bar{w}} \right|$  is large, it is likely that  $\frac{dp_a}{d\bar{w}} < 0$ ,  $\frac{dL_a}{d\bar{w}} > 0$  and  $\frac{d\pi}{d\bar{w}} < 0$ . In concluding, it can be said that, when  $\pi$  is small, it is likely that  $\frac{dy_a}{d\bar{w}} > 0$ .

#### 4. Empirical Analyses of Extended Model

##### 4.1. Data

The empirical analysis aims at verifying some of the comparative static analysis results as well as some of the behavioral equations in the extended model. We use data on Ghana for the empirical analyses and it covers a period of 30 years (1970-1999)<sup>23</sup>. The main data sources are the Statistical Service of Ghana and International sources like the World Bank's World economic Indicators and the International Labour Organization.

Like the situation in most developing countries, data collection and its importance still receives little attention from the government. The result is that there is limited time series data for some variables like unemployment rate, agricultural or industrial wages and migration. Having these shortcomings in mind, various plausible proxies and derivations were adopted for some of the variables. The assumption that rural area economic activity is mainly agriculture and that of urban area is industries and services guided us in the derivation of some variables like rural and urban per-capita incomes and levels of infrastructure. Firstly, capital stock formation was construed to represent level of infrastructure. The argument is that for a developing country like Ghana, a large portion of capital investment goes to the improvement of infrastructure facilities like schools,

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<sup>23</sup> We used the GDP deflator at 1995 prices to convert all nominal values into real values.

hospitals water and sewerage, electricity provision and roads. The perpetual inventory method was used to obtain the Capital Stock (CS) from Gross Fixed Investments (GFI) for the whole country.<sup>24</sup> This was then divided into urban and rural capital stock using percentage of respective per-capita incomes. Per-capita incomes were calculated as real output in a sector divided by the mid-year population of the corresponding area. Agriculture output was used as output for rural area whilst industry and services output were used as output for the urban area. Rural output therefore includes forestry, hunting, and fishing, as well as cultivation of crops and livestock production. Urban output also includes mining, manufacturing, construction, electricity, water, and gas. Also, it includes wholesale and retail trade, transport, government, financial, professional, and personal services such as education, health care, and real estate services. Labour force represents the number of economically active in the age group of 15 to 64 years. Based on the assumption of equal labour participation rate (LFPR) in rural and urban areas, rural and urban labour forces were obtained using the following equation.

$$L_x = LFPR * Population_x,$$

where  $x = rural, urban,$       $L = labor\ force$

The migration data was obtained from the growth in urban labour force. Ideally, such data has to be adjusted for natural increase through birth. Nevertheless, due to non-availability of credible year to year demographic data, the growth in urban labour force was used to represent the migration rate. At a constant rate of natural increase, it is hoped

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<sup>24</sup> Capital stock is evaluated by  $CS_t = (1 - \delta)GC_{t-1} + GFI_t$  where t is current year and t-1 is the previous year.  $\delta$  is the depreciation rate of total capital in the overall economy and it is estimated as 5.83% representing the average depreciation rate for all sectors of the economy. We use the 1970 gross investment as the initial capital.



that this approach would not affect the results considerably. Alternatively, the percentage of urbanized area in the country is used as a variable representing the consequence of migration. Data on unemployment used here was obtained from the International Labour Organization and it represents those who voluntarily register with labour agencies as being unemployed. It is therefore considered to be just a fraction of the actual unemployed. In the absence of any other credible data, this was used to calculate the unemployment rates of the urban area.

#### *Use of Dummy Variable*

The early 1980's in Ghana's history marked a period when the country went through both political and economic changes that affected it in many ways. Naturally, these changes are expected to be reflected in the economic indicators such as unemployment as well as movement of people through migration. Thus, a dummy variable is introduced in 1982 to capture the effect of such a structural change. We define the dummy  $D$  as follows:

$$D = \begin{cases} 0: & t = 1970-1981 \\ 1: & t = 1982-1999 \end{cases}$$

#### *4.2. Equation System for Empirical Analysis*

Due to data limitation, not all the theoretical outcomes are verified empirically. Thus, the empirical analysis developed for testing the theoretical model cannot be exactly the same as the eight-equation system used in the comparative static analysis. At best, the empirical analysis is done with the assumption that the equations used are only a subset of the entire equilibrium system. This is because not all of the variables are easily observable or available. For instance, the utility as described in the theoretical model

cannot be observed. Also, there were no data on some of the endogenous variables such as  $L_m, L_i$  and  $y_i$ . Therefore, we resort to the use of urban population  $L_u (= L_m + L_i)$  since that is available while  $y_i$  is assumed to be zero. It is further noted that while the system of the extended Harris-Todaro model describes an equilibrium condition where equal utility is attained by both rural and urban residents, in reality, migration occurs due to utility difference between the two areas. Therefore we test the hypotheses about the sensitivity of migration, amenity effects in the form of infrastructure, and the *Todaro paradox*. The behavioral equations that are investigated are those for migration, unemployment rate and the agricultural per-capita income. For the migration, we estimate by the urban population growth rate equation

$$\frac{L_{ut}}{L_{ut-1}} = H(E(U_{ut}) - U_{at}) = h(\pi_t, \bar{w}_t, y_{at}, G_{ut}, G_{at}) \quad (38)$$

and alternatively by the urbanization rate equation

$$\frac{L_{ut}}{L_t} = H(E(U_{ut}) - U_{at}) = h(\pi_t, \bar{w}_t, y_{at}, G_{ut}, G_{at}) \quad (39)$$

where  $H$  is a function of utilities difference and  $h$  is a function of the variables that together determine the migration movement. We adopt this approach since the data on the movement of migrants between rural and urban areas is not available. It is expected that urban infrastructure and the minimum wage have positive effects on migration while unemployment rate, agricultural income and rural infrastructure all have negative effects on migration.

The unemployment rate is estimated by

$$\pi_t = 1 - \frac{L_{mt}}{L_{ut}} = k(\bar{w}_t, G_{ut}, L_{ut}) \quad (40)$$

and we expect that urban formal labour and the minimum wage have positive effect on unemployment rate while urban infrastructure has negative effect on unemployment rate.

We estimate the real agricultural per-capita income by

$$\tilde{y}_{at} = \frac{Y_a(L_a, G_a, \bar{N})}{L_a} = f(L_t - L_{ut}, G_{at}) \quad (41)$$

where it is expected that the effect of  $G_{at}$  is positive while that of  $L_t - L_{ut}$  is negative.

#### 4.3. Estimation Using Two- Stage Least Square Method

A two-stage least square method is used in the analysis since the simultaneous equation system of (38) or (39), (40) and (41) are not recursive. In the first stage called the reduced form, ordinary least square estimations of all the endogenous variables are done using all the exogenous variables. In the second stage, the estimates of the endogenous variables obtained in the first stage are then used in place of endogenous variables appearing on the right hand side of the equations.

##### a) Exogenous Effects from the Reduced Form Estimation

We first estimate the reduced form equations of urban labour force, the unemployment rate and the agriculture per-capita income. These are reported in Table 4 where the figures in parenthesis are t-values. It is noted that the coefficients of the explanatory variables in the reduced form equations correspond to the results of comparative static analysis in Table 2. The most concerned exogenous effect is that of urban infrastructure stock on unemployment rate  $d\pi/dG_u$ . The coefficient of  $G_u$  in the unemployment rate equation is positive and significant at 10% level. As discussed in 3.3, this coefficient is

*necessarily negative* in a basic Harris-Todaro model where no amenity effect is explicitly incorporated in the utility function of migrants and also government's budget for public investment is not considered. Therefore, the significant positive coefficient obtained here is interpreted as an indication that amenity difference effect on migration decisions is sufficiently large.

**Table 4. Reduced Form Equation Results**

| Exogenous Variables | Endogenous Variables | $\ln L_{ut}$        | $\ln \pi_t$        | $\ln y_{at}$       |
|---------------------|----------------------|---------------------|--------------------|--------------------|
| <i>C</i>            |                      | -30.081<br>(-5.800) | 8.034<br>(0.071)   | 85.856<br>(1.296)  |
| <i>D</i>            |                      | -0.009<br>(-1.722)  | -0.359<br>(-3.200) | -0.251<br>(-3.824) |
| $\ln G_{at}$        |                      | -0.004<br>(-0.495)  | 0.215<br>(1.375)   | 0.461<br>(5.029)   |
| $\ln G_{ut}$        |                      | 0.008<br>(0.791)    | 0.292<br>(1.400)   | -0.623<br>(-5.106) |
| $\ln L_t$           |                      | 0.816<br>(7.594)    | -1.105<br>(-0.471) | 2.384<br>(1.736)   |
| $\ln \bar{w}_t$     |                      | 0.046<br>(5.064)    | 0.313<br>(1.584)   | 0.196<br>(1.700)   |
| <i>Time</i>         |                      | 0.015<br>(4.949)    | -0.006<br>(0.085)  | -0.047<br>(-1.211) |
| $R^2$               |                      | 0.999               | 0.870              | 0.916              |
| DW                  |                      | 1.131               | 2.428              | 2.061              |

As shown in the comparative static analysis in Table 2, increased urban infrastructure stock necessarily increases urban employment ( $L_m$ ) but the effects on urban unemployed

( $L_i$ ) or agriculture labour ( $L_a$ ) are ambiguous.

The results also show that the coefficients of  $G_u$  in the  $y_a$  equations are negative and significant at a 1% level. These suggest that rural population increases by a U-turn phenomenon. On the other hand, the coefficient of  $G_a$  in the  $y_a$  equations are significantly positive, implying that agriculture productivity is eventually increased by an increase in  $G_a$ . The effect of  $G_a$  on  $L_u$  is seen to be insignificant. This result is acceptable since theoretically, increases in  $G_a$  has no effect on  $L_m$ . In the case of the effects of a change in  $\bar{w}$ , we note that theoretically, they are ambiguous except for its effect on urban unemployment (that is  $dL_m/d\bar{w} < 0$ ). In the estimation, the coefficient of  $\bar{w}$  is positive in the  $L_u$  equation and significant at 1% level. This suggests that the number of the unemployed people mainly increases in response to an increase in the minimum wage level. This is because the expected income in the urban areas increases as the minimum wage increases. Also, the coefficient of  $\bar{w}$  in the  $\pi$  equation is positive and significant at 10% level. This is intuitively acceptable since increased minimum wage directly reduces employed workers in the urban sector. Thus the *Todaro paradox* does not occur in this situation. In the  $y_a$  equation, the coefficient of  $\bar{w}$  is significantly positive implying the situation where  $dL_a/d\bar{w} < 0$  occurs. This is consistent with the result of  $dL_u/d\bar{w} > 0$ . Finally, as is theoretically expected,  $L_u$  increases as  $L$  increases. The sign of the coefficient of  $L$  in the  $\pi$  equation is unexpectedly negative although it is insignificant. On the other hand,  $L_a$  theoretically increases with an increase in  $L$ .

indicating that real agricultural income  $y_a$  decreases. However, the coefficient of  $L$  in the  $y_a$  equation is positive and significant at 10% level, which is a contradiction.

*b) Results of the Behavioral Equations*

The behavioral equations are estimated by the second stage of the two-stage least square method.

*i) Model of Migration (Urban Population Growth)*

The estimated equations for the urban population growth rate are as shown by equations (42) and (43). In equation (42), the coefficient of  $\pi$  is negative and significant at 1% level as expected. Moreover, the coefficient of  $\ln(G_{ut}/G_{at})$  is positive and highly significant.

$$\ln \frac{L_{ut}}{L_{ut-1}} = -0.017 - 0.006 D - 0.030 \ln \hat{\pi}_t - 0.001 \ln \frac{\bar{w}_t}{\hat{y}_{at}} + 0.009 \ln \frac{G_{ut}}{G_{at}} \quad (42)$$

$R^2 = 0.915 \quad DW = 1.423$

$$\ln \frac{L_{ut}}{L_{ut-1}} = 0.031 + 0.009 D + 0.001 \ln \frac{G_{ut}}{G_{at}} + 0.009 \ln \frac{(1 - \hat{\pi}_t) \bar{w}_t}{\hat{y}_{at}} \quad (43)$$

$R^2 = 0.739 \quad DW = 0.981$

It can also be seen that the amenity difference between the two areas is an important pull (and push) factor for migration. However, the coefficient of income ratio  $\ln(\bar{w}_t/y_{at})$  is unexpectedly negative although it is statistically insignificant. In equation (43) where the expected income ratio  $((1 - \hat{\pi}_t)\bar{w}_t/\hat{y}_{at})$  is incorporated instead of the raw income ratio  $\bar{w}_t/\hat{y}_{at}$ , the effect of expected income difference on migration is significant while infrastructure difference has an insignificant effect. These outcomes suggest that the

estimation result is very sensitive to whether the unemployed rate  $\pi$  is separately introduced or not. This coincides with the observation in Salvatore (1981) that an individual tends to react sensitively to the unemployment rate independently of income difference. Thus, it is found that labour market condition is crucial for migration decision.

ii) *Model of Migration (Urbanization Rate)*

When the urbanization rate is used as the representation of migration result,  $G_{ut}$  has a significantly positive effect on urbanization rate as seen from (44). This suggests that better amenity attracts more migrants even though they cannot be employed. Also, the coefficient of the expected income difference is positive as expected and it has a 10% significant level.

$$\ln \frac{L_{ut}}{L_t} = -2.368 + \underset{(2.577)}{0.021} D + \underset{(0.261)}{0.008} \ln G_{at} + \underset{(2.928)}{0.076} \ln G_{ut} + \underset{(1.513)}{0.050} \ln \frac{(1 - \hat{\tau}_t) \bar{w}_t}{\hat{y}_{at}} \quad (44)$$

$$R^2 = 0.976 \quad DW = 0.745$$

It is further noted that although the coefficient of  $G_{at}$  is unexpectedly positive, it is statistically insignificant even at 10% level to warrant any concern. The dummy variable  $D$  introduced to capture the structural effects on migration has a positive coefficient which is significant at 5% in (44). This might mean that migration represented by percentage urban increased after 1982.

iii) *Unemployment Rate Model*

For the unemployment rate, it is seen from (45) that the dummy variable is significantly negative. This indicates that the structural adjustment carried out around 1982 resulted in a considerable lowering of the unemployment rate after 1982.

$$\ln \pi_t = 4.025 - 0.386D - 3.932 \ln G_{ut} - 2.102 \ln \hat{L}_{ut} + 0.184 \ln \bar{w}_t + 0.002 \text{Time} * \ln G_{ut} \quad (45)$$

(-3.449)                      (-0.541)                      (-1.248)  
(1.316)                      (0.611)

$$R^2 = 0.859 \quad DW = 2.311$$

Regarding the effect of  $G_{ut}$  on the unemployment rate, it is theoretically expected that increased  $G_{ut}$  lowers the unemployment rate. This is actually seen in the negative coefficient of  $G_{ut}$  although it lacks any statistical significance. For the minimum wage, its coefficient is positive as theoretically predicted and it is nearly significant at a 10% level.

It is noted that the employment level in the urban area is determined by  $G_{ut}$  and  $\bar{w}_t$ .

Thus, given  $G_{ut}$  and  $\bar{w}_t$ , it is expected that as total urban population increases, the unemployment rate will increase. However, the results obtained indicates that the coefficient of  $\hat{L}_{ut}$  is negative although not significant even at a 10% level. Although this seems to run at variance with our expectation, it yields itself to alternate interpretation. One interpretation is that, urbanization economies due to agglomeration of people in the urban sector is working so as to increase the production efficiency. Thus, urban sector creates more opportunity for employment.

*iv) Agricultural Per-capita Income Model*

The results of the agricultural income model is as given by (46). Here, the coefficient of the estimated rural population ( $L_t - \hat{L}_{ut}$ ) is negative as expected and it is significant at a 5% level.



$$\ln y_{at} = 16.667 - \underset{(-2.961)}{0.178} D + \underset{(1.007)}{0.052} \ln G_{at} - \underset{(-2.250)}{0.555} \ln(L_t - \hat{L}_{ur}) \quad (46)$$

$$R^2 = 0.814 \quad DW = 1.568$$

The coefficient of the rural infrastructure is positive as expected but insignificant. This might suggest that injection of public capital into the rural area has not been effectively carried out for agricultural production. The coefficient of the dummy variable is negative and it is highly significant. This might be due to the fact that the structural adjustment made from the early 1980's negatively affected the agriculture sector. For instance, the restructuring period also witnessed a reduction in subsidies of agricultural inputs. According to a report by the Food and Agriculture Organization of the United Nations (1994), Ghana in the early stages of the Economic Recovery Programme removed subsidies on fertilizer which is an important input in the agriculture production.

## 5. Conclusions

This paper has developed and verified an extended model of rural-urban migration in developing countries where infrastructure's amenity effect on migration has been shown to be very pronounced. The theoretical model builds on the celebrated Harris-Todaro model and we include infrastructure level and government budget for infrastructure and unemployment benefit in the analysis. The paper argues that when there exists disparities in amenity-creating infrastructure among cities and the hinterlands of developing countries, people are compelled to migrate from the rural areas to urban areas. Thus, the long held notion of income difference alone accounting for the mass movement of rural people to urban areas in developing countries may be an overstatement of causes of rural-urban migration in such countries. We find from the extended model that the effect of the

urban infrastructure on equilibrium utility is positive whilst that of the rural infrastructure can be negative or positive. In particular, the rural infrastructure effect is negative when agriculture production increases as a result of rural infrastructure. In this situation, the price of rural output is lowered causing a loss in utility. We also obtained the result that the effect of rural infrastructure on agriculture price is negative whilst the effect of urban infrastructure is positive. This means that if more infrastructures are provided in the rural area, agriculture production will relatively increase. The empirical estimations indicate that the amenity difference between the two areas is an important push or pull factor for migration to occur. In the case of the behavioral equations, it is seen that the unemployment rate in the urban area, that is labour market conditions, is a crucial factor for migration to occur.

Concluding, it can be said that the outcomes of the theoretical and empirical analysis point the fact that people will move to where they feel comfortable in terms of income and amenities. Since our findings suggest that it is not only income difference but also infrastructure or amenity difference do have strong effect on migration, it is necessary for governments to tackle the issue of infrastructure provision especially in the rural areas, more seriously. This is because the presence of infrastructure in the form of amenities such as good drinking water and electricity will not only enhance the lives of residents but also, it will promote the setting up of various agro-based industries which are dependent on the presence of these infrastructure to function. Eventually, living standards of rural areas can improve and migration will not be taught as lucrative any more. In the urban area, since it is realized that the setting of the minimum wage has the tendency of

triggering more people to move into the urban areas, it has to be done with due recognition that its repercussion effects can outweigh the intended benefits. The same argument goes for the provision of urban infrastructure where, a balanced thought that considers the overall benefits derived from the provision of infrastructure has to be the guiding principle.

## Appendix

### List of Basic Assumptions

|                          | Description  |
|--------------------------|--|
| $Y_{aL} > 0$             | Marginal product of agriculture labour is expected to be positive although very small.   |
| $Y_{aG} > 0$             | Marginal product of agriculture infrastructure is positive to reflect the fact that increase in infrastructure causes output to increase as well.  |
| $Y_{mL} > 0$             | Marginal product of urban formal labour being positive indicates that urban productivity increases with increase in labour at least to the point when additional labour input will cause the marginal product to fall. |
| $Y_{aLG} > 0$            | Effect of rural infrastructure on agriculture marginal product of labour is positive to show that infrastructure input can improve the marginal product of labour  |
| $Y_{aLL} < 0$            | Effect of rural labour on agriculture marginal product of labour is negative implying that further increase in labour causes the marginal labor to fall.   |
| $Y_{mLL} < 0$            | Effect of urban labour on urban marginal product of labour. The same reasoning given for $Y_{aLL}$ applies.  |
| $Y_{mLG} > 0$            | Effect of urban infrastructure on urban marginal product of labour is expected to be positive since infrastructure can improve the marginal product of labour.   |
| $\gamma' = \gamma_k < 0$ | The effect of the relative outputs of urban and rural goods on the price of the agriculture good is negative.  |
| $Y_{mG} > r$             | This shows that government does not increase urban infrastructure unless its direct effect (income increase) exceeds cost.   |
| $W_{y_a} > 0$            | Effect of rural income on rural utility being positive shows that increase in rural income can improve the welfare of rural residents.   |
| $Z_{G_a} > 0$            | Effect of rural infrastructure on rural utility is positive to show that infrastructure availability improves the welfare of rural residents.  |
| $W_{y_i} > 0$            | Effect of unemployment benefit on urban utility is positive to give  |

|               |   |
|---------------|---|
|               | meaning to the fact that unemployment benefit can raise the living conditions of the unemployed.  |
| $Z_{G_u} > 0$ | Effect of urban infrastructure on urban utility is positive to indicate that presence of infrastructure in the urban area enhances utility. |

Based on the assumptions, the following are derived:

$$-\gamma_k \frac{Y_{aL}}{Y_m} > 0, \quad \gamma_k \frac{Y_a Y_{mL}}{Y_m^2} < 0, \quad \gamma_k \frac{Y_{aG}}{Y_m} < 0, \quad -\gamma_k \frac{Y_a Y_{mG}}{Y_m^2} > 0$$

$$[Y_{mL} - (1-t_L)\bar{w}] > 0, \quad L_m \bar{w} > 0, \quad (1-Y_{mG}) < 0, \quad (1-t_L)L_m > 0$$

$$-W_{y_a} < 0, \quad Z_{G_a} > 0,$$

$$[W((1-t_L)\bar{w}) - W(y_i)] > 0, \quad (1-\pi)W_{t_L} \bar{w} > 0, \quad \pi W_{y_i} > 0,$$

$$Z_{G_u} > 0, \quad [(1-\pi)(1-t_L)]W_{\bar{w}} > 0$$

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