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# The development of Huambo/Angola. The application of a spatial interaction model to simulate the movement from autarky to external integration

(assigned to session **D**)

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## Abstract

Huambo province in Angola has been detached from the outside world since the beginning of the nineties. This was due first to the civil war in Angola and from then on due to the degradation of roads and destruction of railways. Furthermore there is the lack of integration of the province itself due to transport difficulties and human desertification. The objective of this paper is to understand the role of the roads network and the distribution of public funding in the revival of the economy in the Province of Huambo. First we present a review of the literature that stresses that one of the major causes of poverty due to war is related to the lack of accessibility. Then we formulate, calibrate a spatial interaction model for the Huambo City and Province where the degree of openness of the economy can be highlighted. Finally we simulate the model for different scenarios of road network and distribution of public funds.

## 1) Introduction

Angola is fabulously rich country in resources but a nation overwhelmed by poverty (Werlin, 2003). One of the main causes of poverty is attributed to civil war (Goodhand, 2003) that lasted from 1974 till 2002. During that period many regions in the interior, survived isolated from the outside world. The only economic link with the outside world was based on public transferences for the provincial government and humanitarian aid distributed by churches and NGOs. Most of the connections were made by plane or by irregular convoys of humanitarian aid. Exports have disappeared, investment vanished, infrastructures become degraded and the economy become autarchic. The only economic link with the outside world was based on public transferences for the provincial governments, on bilateral and multilateral aid schemes strongly associated with wars (Chauvet, 2003), and on humanitarian aid distributed by churches and NGOs. Nowadays road and train linkages linking to the coast are being re-established and new opportunities for public and private investment are arising but the spatial picture if these phenomena are still uncertain due to the biased distribution of public funds and infrastructures.

There are two different effects associated with these investments: In the short term, and from the demand perspective, there are income multiplier effects namely from public spending on infrastructures and administration. In the long term, and after the reconstruction of key infrastructures and deployment of private capital, there are the supply effects on growth due to increased productivity, in rural and urban areas, and to the development of scale and scope economies mainly in the urban areas. The spatial and social distribution patterns of these effects are very important since one of the main problems of the existing system of aid is that it contributes to growing regional and social inequality (Pfeiffer,2003). As stressed by C. Cramer (2002) the frustration of dispossessed farmers in Angola is one of the main causes of the Angolan conflict. The model developed in this paper tries to address those issues, only from the demand perspective, through the understanding of the spatial pattern of income multiplier effects due to public spending on infrastructures and administration. By showing the distribution effects of public spending we also aim to inform the institutional reform that, according to Elizabeth Asiedu (2003), must be part of the development policies.

Based on the literature and a few assumptions, we formulate a spatial interaction model where it is possible to distinguish between autarchic and open basic employment and derive multiplier spatial effects on employment and population (point 2). Then we treat data from official sources and local inquiries to calibrate and simulate a spatial interaction model for the City and Province of Huambo (point 3). Finally we propose some conclusions and recommendations for the allocation policies in the Province of Huambo (point 4).

## 2) Spatial Interaction Model for Open, Autarchic and Mixed Economies

### 2.1 Base Model

A region is by definition and open system (Polèse, 1998) which economy is strongly influenced by its exports and by external support and external remittances. On the same line economic base theory stresses that regional exports play a strategic role in regional development (Costa et al., 2002). The central idea of the Base Model (Hoyt, 1939; North, 1955; and Tiebout, 1956) is that the regional economy, valued by income or employment, derives mainly from the impacts of regional exports and external supports. This is explained by indirect production interdependencies and through income multiplier effects. From this perspective the regional rate of growth is determined by the exports growth and by the external support dynamism.

The multiplier effect of the Base Model is explained below:

(1) $Et = Eb + Ec$

(2) $Ec/P = s$

(3) $P/Et = r$

Where Et = total employment; Eb = basic employment; Ec = non basic employment; P = Total Population. From (1), (2) and (3) it is possible to derive the multiplier effect of the basic employment on the total employment and on the total population.

(4) $Et = [1/(1-rs)]\ Eb$

(5) $P = [r/(1-rs)]\ Eb$

The model can also be expressed in terms of income or activity (A) assuming that every employment has the same productivity (q).

(6) $At = q\ Et$

(7) $Ab = q\ Eb$

(8) $At = [1/(1-rs)]\ Ab$

And, when q=1.

(9) $At = [1/(1-rs)]\ Eb$

Figure 1 explains the multiplier effect of the Base Model. In the first moment it is possible to estimate the population dependent on the basic activity just by multiplying its amount by the inverse of the activity rate (r). In the second moment the existing demand induces the development of non basic activity which estimate is obtained by multiplying the demand by the coeficient (s). In a third moment the non basic activity is associated with more dependend population. The second and third moment are repeated iteralively until the Total Employment/Activity and Total Population/Demand derived from the model converges to new levels consistent with the conditions presented in (1), (2) and (3).

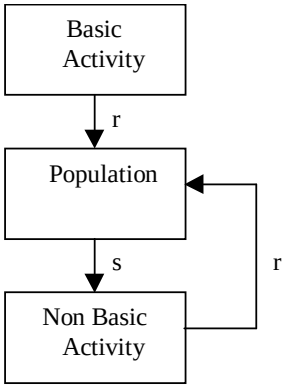


Figure 1: Base Model in an Open Economy

**2.2 Base Model for an Autarchic Economy**

The Base Model explained above assumes that all the economy is in full employment and that the only determinants of the economic system are the exports. In this section we try to adapt that formulation to an autarchic region.

For an autarcic economy the basic activity does not result from the exports but from the demand generated by the existing population (Pat) weighted by the inverse of the activity rate (Pat/r). Nevertheless, the total activity (Aat) generated by the multiplier must be deduced by the initial basic activity (Pat/r) which, in fact, did not occour in the economy. Expression (10) represents this reasoning.

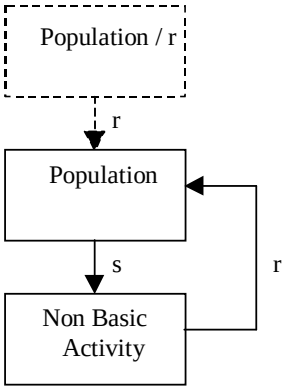


Figure 2: Basic Model in an Autarchic Economy

(10) $Aat = q\,[1/(1-rs)]\,(Pat/r) - (Pat/r)$

(11) $Aat = q\,[rs/(1-rs)]\,(Pat/r)$

Therefore the income multiplier effects in an autarchic economy (Aat) is only a part (rs) of the open economy. When the productivity is equal to 1 (q=1) expression (11) can be expressed as follows:

(12) $Aat = [rs/(1-rs)]\,(Pat/r)$

(13) $Aat = [s/(1-rs)]\,Pat$

**2.3 - Base Model for a Mixed Economy**

Finally, taking into account that a developing economy can be partially open to the outside world it is possible to derive a model with open and autarchic basic employment. The assumption is that total population is kept constant and exogenous (Pt) so that the autarchic population (Pat) is the equivalent of a population not involved in the open economic multiplier effect.

(14) $Pat = Pt - [r/(1-rs)]\,Eb$

After few calculations, and for q=1, the multiplier effect for an open and autarchic economy is given by:

(15) $At = [1/(1-rs)][1-rs/(1-rs)]\,Eb + s/(1-rs)\,Pt$

Notice that, if the population is taken as tottally endogenous, the multiplier will be similar to the one presented in the Base Model (9). Furthermore when the Basic Employment (Eb) is equal to zero then the multiplier is equivalent to the one explained in the Base Model for an Autarchic Economy (13).

Figure 3 explains the multiplier effect of the Base Model for a Mixed Economy.

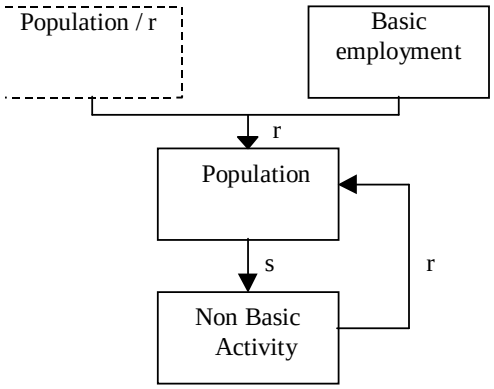


Figure 3: Base Model for a Mixed Economy

**2.2 Spatial Interaction Model for a Mixed Economy**

A spatial interaction model distributes the activity and the population by the different areas of the region taking into account the distances between those areas and their attractivity (Dentinho, 2002). In Figure 4 it is presented a spatial interaction model for a mixed economy.

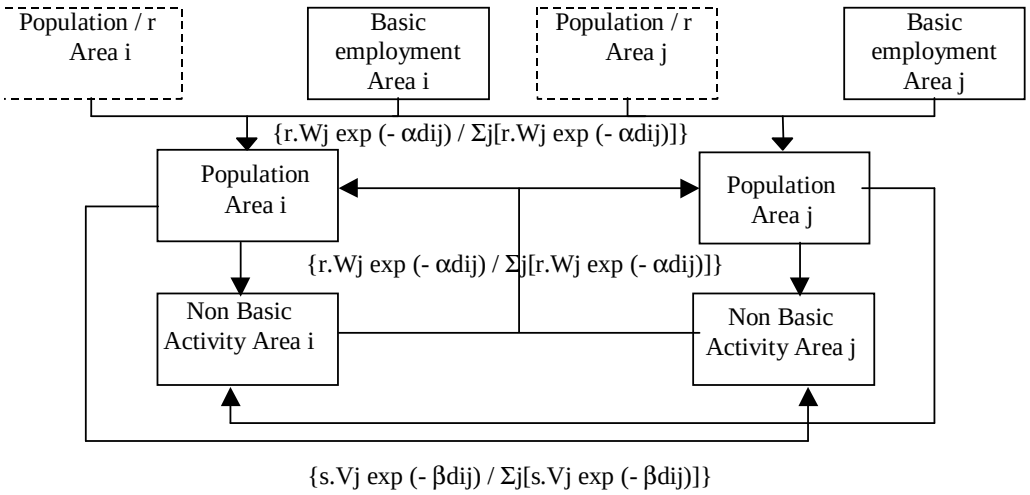


Figure 4: Spatial Interaction Model for a Mixed Economy

The

(16) $$Tij = Ai \{r.Wj \exp(-\alpha dij) / \Sigma j[r.Wj \exp(-\alpha dij)]\}$$

(17) $$Pj = \Sigma i\ Tij$$

Where: Tij = population that lives in j and depend on the activity in i; Ai = activity in i; Wj = residential atractivity of j; r = inverse of the activity rate; $\alpha$ = parameter that

defines the atraction produced by distance for the commuters; dij = distance between i and j; and Pj = residents in j. Notice that in the first iteration Ai = (Pi/r+Ebi).

(18) $$Sij = Pi \{s.Vj \exp (- \beta dij) / \Sigma j[s.Vj \exp (-\beta dij)]\}$$

(19) $$Ej = \Sigma i\ Sij$$

Where: Sij = activity that generated in j that serves the population in i; Ai = activity in i; Vj = activity atractivity of j; s = amount of activity per population; $\beta$ = parameter that defines the atriction produce by distance for the people that look for activity services; dij = distance between i and j; and Ej = employment in j.

Figure 4 explains the functioning of the spatial interaction model. In the first moment it is possible to estimate the population of the different areas dependent on the basic activity of various areas just by multiplying its amount by the proportion of depedents on activity of area i which lives in area j $\{r.Wj \exp (- \alpha dij) / \Sigma j[r.Wj \exp (- \alpha dij)]\}$. In the second moment the existing population for each area i induces the development of non basic activity in the different areas which estimate is obtained by multiplying the population of area i by $\{s.Vj \exp (- \beta dij) / \Sigma j[s.Vj \exp (-\beta dij)]\}$. In a third moment the non basic activity in the various areas is associated with more dependend population across the various areas. The second and third moment are repeated iteralively until the Total Employment/Activity and Total Population/Demand derived from the model converges to the to new levels consistent with the conditions presented in (1), (2) and (3).

**3) Spatial Interaction Model for the Huambo Province**

**3.1 Data collection**

Huambo region registered a major conflict from 1992 till 2002. Therefore data from that period is quite difficult to obtain. In order to minimise this limitation we combine four sources of information:

a) Official data from the Province of Huambo to obtain data on population distribution, distribution of public employment and distances between different areas;

b) A questionnaire to 178 families of Huambo to estimate the activity rate, the relation between basic and non basic activity and the relation between non basic activities and population.

c) Interviews with persons close to security forces and NGOs to estimate the location of employment in those sectors.

d) Interviews with experts from Huambo to evaluate the average distance between residence and employment and between residence and non basic services.

Based on these sources we estimate the following data:

a) Indicators to calibrate the model: the average distance between residence and employment, the average distance between residence and non basic activities, the inverse of the activity rate and the relation between non-basic activities and population (Table 1)

b) The distribution of population and basic employment in Huambo region (Table 2);

c) The distance matrix between the different areas (Table 3)

| | |
|---|---|
| Inverse of the activity rate | 3,406 |
| Relation between non-basic activities and residence | 0,155 |
| Average distance between residence and employment | 1,7 |
| Average distance between non basic activity and residence | 3,9 |

Table 1 Model Indicators for Huambo

| N/O | Areas | Population | Basic Employment |
|---|---|---|---|
| 1 | Cidade Alta | 41420 | 6462 |
| 2 | Bairro Académico | 22303 | 2807 |
| 3 | Cidade Baixa | 54165 | 10377 |
| 4 | São Pedro | 158055 | 1092 |
| 5 | Cacilhas | 137774 | 1134 |
| 6 | São João | 80361 | 1349 |
| 7 | Benfica | 83830 | 964 |
| 8 | Chiva/Chianga | 36833 | 915 |
| 9 | Aeroporto | 44606 | 6634 |
| 10 | Bairro Militar | 34814 | 10696 |
| 11 | Municípios | 1661292 | 40847 |
| | Total: | 2355453 | 83275 |

Table 2 Population and Basic Employment in Huambo Areas

| | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Areas | Cidade Alta | B.Académico | Cidade Baixa | São Pedro | Cacilhas | São João | Benfica | Chiva/Chianga | Aeroporto | Bairro Militar | Municípios |
| 1 | Cidade Alta | 0,4 | 1,2 | 1,4 | 1,3 | 3 | 4,7 | 2,6 | 10 | 3,2 | 1,4 | 23,3 |
| 2 | B.Académico | 1,2 | 0,4 | 1,2 | 2,6 | 1,7 | 3,5 | 2,5 | 8,5 | 2,4 | 2,6 | 24,6 |
| 3 | Cidade Baixa | 1,4 | 1,2 | 0,5 | 2,7 | 2 | 2,3 | 1,3 | 7,3 | 3,2 | 2,8 | 24,7 |
| 4 | São Pedro | 1,3 | 2,6 | 2,7 | 0,6 | 4,2 | 5 | 4 | 11,3 | 4,6 | 2,7 | 22,6 |
| 5 | Cacilhas | 3 | 1,7 | 2 | 4,2 | 0,6 | 1,8 | 3,3 | 6,8 | 3,7 | 4,4 | 26,2 |
| 6 | São João | 4,7 | 3,5 | 2,3 | 5 | 1,8 | 0,6 | 3,6 | 5 | 5,5 | 6,1 | 27 |
| 7 | Benfica | 2,6 | 2,5 | 1,3 | 4 | 3,3 | 3,6 | 0,7 | 8,6 | 4,5 | 4 | 26 |
| 8 | Chiva/Chianga | 10 | 8,5 | 7,3 | 11,3 | 6,8 | 5 | 8,6 | 1 | 10,5 | 11,4 | 33,3 |
| 9 | Aeroporto | 3,2 | 2,4 | 3,2 | 4,6 | 3,7 | 5,5 | 4,5 | 10,5 | 0,4 | 3 | 26,6 |
| 10 | Bairro Militar | 1,4 | 2,6 | 2,8 | 2,7 | 4,4 | 6,1 | 4 | 11,4 | 3 | 1 | 24,7 |
| 11 | Municípios | 23,3 | 24,6 | 24,7 | 22,6 | 26,2 | 27 | 26 | 33,3 | 26,6 | 24,7 | 0,5 |

Table 3: Distances between areas [Dij]

### 3.1 Model calibration

The attractivity factors for non-basic activities Vi are defined ex-ante taking into account the relative importance of the area in terms of commerce and services for the local population (Table 4). The attractivity factors for residence Wi are adjusted in a circle of calibration external to the one that calibrates iteratively $\alpha$ and $\beta$. To calibrate $\alpha$ and $\beta$ we use the *solver* function of the Excel Software for Windows. $\alpha$ and $\beta$ are chosen so that the Average distance between residence and employment and the Average distance between non basic activity and residence(Table 1) are similar to the respective values estimated by the Model. The initial values for Wi are similar to the population of each area being adjusted after a first calibration of $\alpha$ and $\beta$ taking into account the difference between the population estimated by the model and the existing population (Table 3).

| | Cidade Alta | Bairro Académi | Cidade Baixa | São Pedro | Cacilhas | São João | Benfica | Chiva/Chianga | Aeroporto | Bairro Militar | Municípios |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Vi | 2 | 3 | 4 | 4 | 1 | 2 | 1 | 1 | 1 | 1 | 1 |
| Wi (initial) | 41420 | 22303 | 54165 | 158055 | 137774 | 80361 | 83830 | 36833 | 44606 | 34814 | 1661292 |
| Correction | 1,17 | 1,02 | 1,36 | 0,40 | 0,42 | 0,56 | 0,46 | 1,46 | 1,57 | 2,52 | 1,19 |
| Wi (final) | 48485 | 22763 | 73933 | 63527 | 58200 | 44651 | 38529 | 53803 | 69990 | 87561 | 1976937 |

Table 4: Non Basic Attractivity Factors and Initial and Final Residential Attractivity Factors

The final value of $\alpha$ and $\beta$ are presented in Table 5.

| | |
|---|---|
| $\alpha$ | 0,232135 |
| $\beta$ | 0,183051 |

Table 5: Calibrated Inertia Parameters for the Movements Empoyment-Residence ($\alpha$) and for the Movements Residence – Non Basic Activities ($\beta$).

### 3.3 Results

Table 5 presents the results of the calibrated model. In the first row we present the total basic activity for each area. This comes not only from basic employment but also from the population that is not associated with this basic employment. The last row is the result of the multiplication if the Total Activity by the inverse of the activity rate.

| | Cidade Alta | Bairro Académico | Cidade Baixa | São Pedro | Cacilhas | São João | Benfica | Chiva/Chianga | Aeroporto | Bairro Militar | Municípios |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Basic Activity | 8720 | 4023 | 13329 | 9706 | 8643 | 5729 | 5533 | 2922 | 9065 | 12594 | 131398 |
| Non Basic Activity | 15704 | 22420 | 30272 | 28465 | 6452 | 11325 | 6249 | 2715 | 5988 | 6659 | 100460 |
| Total Activity | 24424 | 26443 | 43601 | 38172 | 15095 | 17054 | 11782 | 5637 | 15053 | 19253 | 231858 |
| Total Activity x Inverse of Activity Rate | 79127 | 36514 | 121411 | 87817 | 78322 | 51873 | 49914 | 25395 | 80311 | 112405 | 804061 |

Table 5: Distribution of Basic and Non-Basic Activity and of Relative Wealth in Huambo Province

It is also possible to obtain an indicator that expresses the relative wealth of each area (Figure 5) due to different distributions of pre-existing population and basic employment. Actually the ratio between the Last Row of Table 5 (Total Activity x Inverse of Activity Rate) and the Population (third column of Table 2) represents the relative wealth of each area.

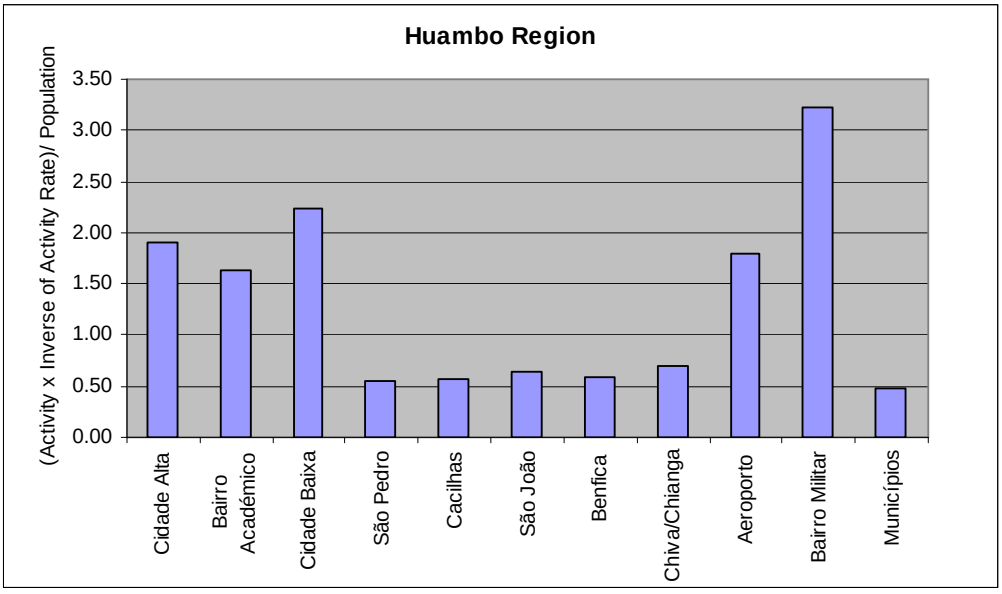


Figure 5: Relative wealth of the different areas of Huambo Province in 2003.

From Figure 5 it is clear that, due to the structure of accessibility and distribution of public funds the wealth spatial distribution in the Province of Huambo in Angola is strongly biased. Actually the areas where there is concentration of public jobs like Bairro Militar, Cidade Alta, Cidade Baixa, Bairro Académico an Aeroporto, which

represents only 8% of the total population of the Province. According to the model they receive on average four times more wealth than their country fellowmen in the other areas. Somehow confirms the statement of C. Cramer (2002) about the frustration of dispossessed farmers in Angola that, on average, have access to much lower wealth than those who live in more accessible areas.

The question is whether it is possible to change the distribution of wealth, based on the assumptions of the model, and through the management of a few decision tools: a) the distribution of basic public employment; b) the organization of markets and centres for non-basic employment; c) or both. From the analysis of Figures 6, 7 and 8 the result depends very much on the starting situation.

In an autarchic situation such as the one that occurred in 1993 (Figure 6).the more central areas influence the distribution of wealth and the situation is similar for any distribution of the basic employment which is close to zero. Nevertheless there is a reduced redistribution effect if some organization of markets and centres for non-basic employment is undertaken in less central areas.

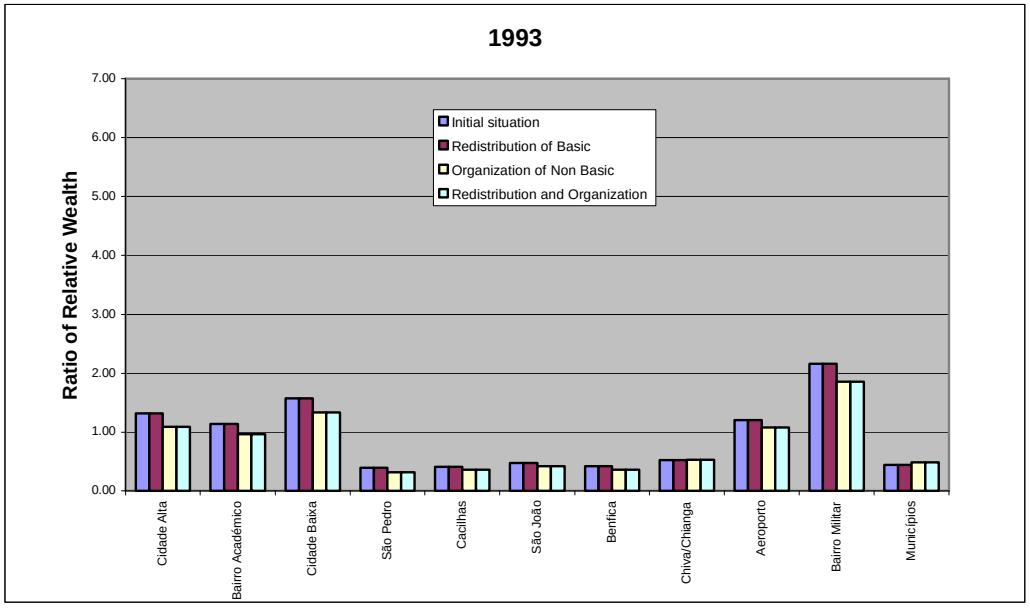


Figure 6: Relative Wealth of Huambo Province in Autarchy.

In a mixed situation, with part of the economy open to the outside world through public transferences, like the one that occurred in 2003 (Figure 7), the effect of a distribution of public basic employment is stronger only in the areas of the province

outside the city of Huambo. On the other hand the organization of markets and centres for non-basic employment produce good effects in the suburbs of Huambo.

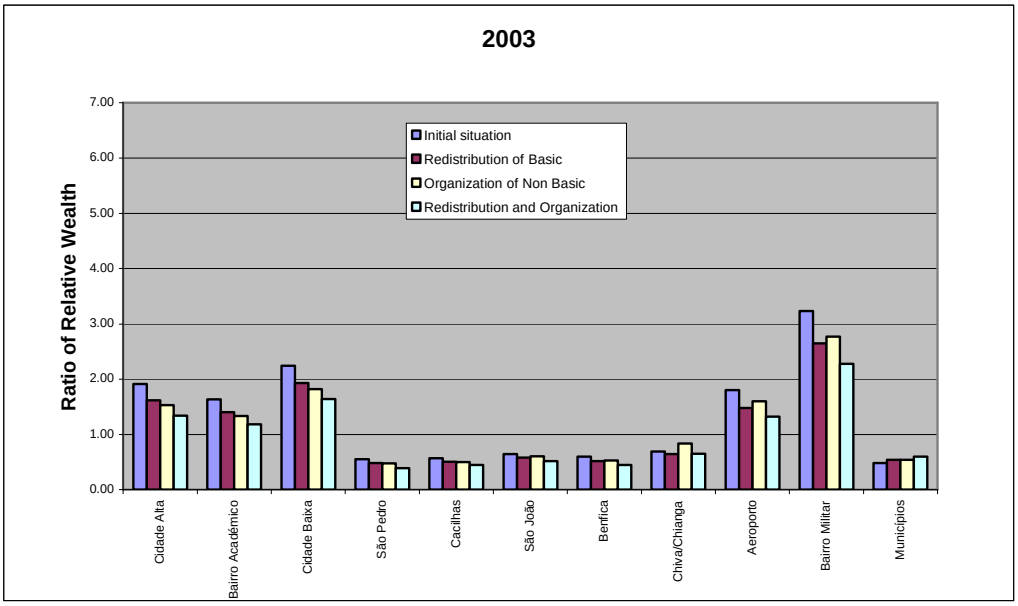


Figure 7: Relative Wealth of Huambo Province in a Mixed Economy.

In an open economy (Figure 8) the more central areas will continue to benefit from the wealth distribution. Notice that the simulation assumed that the basic employment for 2013 has the same distribution pattern as existed in 2003 where public employment has a major role. If basic employment increases in agriculture and industry then the Suburbs of Huambo City and the rural areas of will also benefit.

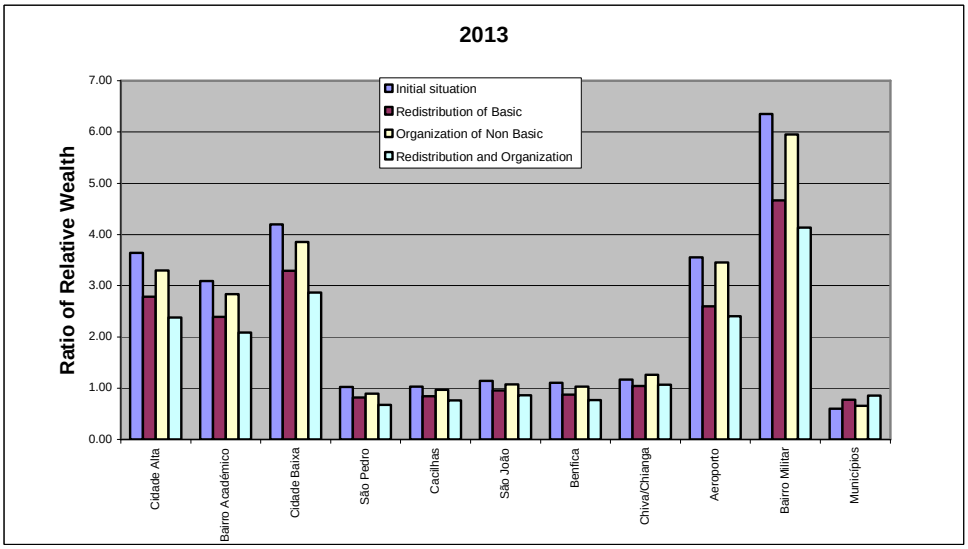


Figure 8: Relative Wealth of Huambo Province in an Open Economy

## 4) Conclusions

In this paper we have tried to understand the role of the distribution of public funding and the structure of accessibility in the revival of the economy in the Province of Huambo. We formulate, calibrate a spatial interaction model for the Huambo City and Province where the degree of openness of the economy can be highlighted and we simulate the model for different scenarios of accessibility, degree of openness of the economy and the distribution of public funds. A few conclusions can be taken.

First, the degree of openness is crucial for the level of wealth of the region. Actually, only based on the design of the model, on the activity rate and on the ratio between non-basic employment and population it is possible to estimate that the movement from a autarchy to an open economy will double the wealth, for the same levels of productivity and the same population.

Second, without any export activity the distribution of public money throughout the territory can have an important role in each locality. Nevertheless the spread effects over the territory of these expenditures will be quite reduced due to the high inertia of distance for poor rural areas.

Finally, only through the creation of conditions for the establishment of basic activities in rural and suburban areas of the Province of Huambo it seems possible to reduce frustration of dispossessed farmers in Huambo which, according to C. Cramer (2002) has been one of the main causes of the Angolan conflict.

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