THE MEASUREMENT OF INTRAMETROPOLITAN GEO-ECONOMIC SPACE IN SOUTH AFRICA: THE PWV AS AN EXAMPLE

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An attempt has been made to develop an economic potential model to facilitate the analysis of the geo-economic space in and around development centres in South Africa. The Pretoria-Witwatersrand-Vaal Triangle area is used as an example to illustrate the quantification of economic potential maps in this study. It is a geometrical model which indicates the geographical extent of gradually changing levels of economic potential, based on economic indicators consisting of population, labour, and income variables. As a normative model, it offers the planner the opportunity of an objective comparison of areas which in terms of development criteria may differ greatly from one another, and as such constitutes an instrument which can be used in conjunction with other conventional research results in the formulation of development policies in the formal economic sector on a regional and supra-regional level.

In die artikel word daar gepoog om 'n ekonomiese potensiaalmodel te ontwikkel wat kan help met die ontleding van geo-ekonomiese ruimte in en om ontwikkelingskerns in Suid-Afrika. Die Pretoria-Witwatersrand-Vaal Driehoek-gebied word as voorbeeld gebruik vir die berekening van ekonomiese potensiaalkaarte in die studie. Die model dui die geografiese omvang aan van geleidelik veranderende ekonomiese potensiaalvlakke, gebaseer op ekonomiese indikatore bestaande uit bevolkings-, arbeids- en inkomste veranderlikes. As 'n normatiewe model bied dit die beplanner die geleentheid om op 'n objektiewe wyse vergelykings te tref tussen gebiede wat in terme van ontwikkelingsmaatstawwe grootliks van mekaar kan verskil. Dit is dus 'n instrument wat in samehang met ander konvensionele navorsingsresultate gebruik kan word in die formulering van ontwikkelingsbeleid in die formele ekonomiese sektor op streek- en multistreekvlak.

1. INTRODUCTION

Since the middle of this century when Perroux (1955) introduced the growth pole concept in abstract economic space, much attention has been given to the development centre cocept[1] in geographical space (Boudeville, 1974: 9-10) as a promising development instrument under varied economic circumstances (eg. Friedmann, 1966; Hermansen; 1972; Hirschman, 1972; Parr, 1973). However, views on its potential as an instrument to create economic spread effects varies. Hirschman (1972:189) sees spread effects as an inevitable force emanating from the polarisation force, while Myrdal (1964: 31-34) regards the polarisation force as almost irreversible. According to Moseley's (1973:74) and Nichols' (1969:199) empirical findings there is evidence that the development centre does create spread effects, especially to surrounding major urban centres and to its immediate hinterland, but not (soon) to peripheral areas further away from such a development centre. The spread effects from development centres depend, according to Hansen (1976:131) on the levels of development of the regions in which the centres are located, which means that spread effects are poor in less developed areas (Hansen, 1978(a):218-220).

The findings that designated so-called 'development centres' (often located in peripheral areas) do not create the significant measures of economic spread effects in their more distant hinterlands as was originally expected from them, may partially be attributed to technological factors. The technological level of the type of industry which is associated with the conventional development centre concept seems to be too advanced generally to be readily accommodated by the economies of underdeveloped communities. According to Richardson (1978:134) an important reason why relatively little success has been experienced with the development centre or 'centre-down' approach in underdeveloped economies is because "... the Western concept of growth poles (emphasising large-scale capital-intensive manufacturing) has been carelessly transplanted to developing countries without sufficient modification to the economic and social conditions prevailing in these countries". This also seems to be the case in South Africa (Geyer, 1989). Subsequently, disappointment amongst development scholars with the results of the conventional development centre concept as a working tool in the development process in underdeveloped areas has led to a shift in emphasis either towards the so-called 'grassroots' or towards a development centre approach adapted to Third World economic circumstances (Conroy, 1973: 378-380; Lo & Salih, 1978; Coetzee, 1986:384).

In South Africa, the concept of 'border area' industrial development – i.e. the so-called 'growth points' – was at first introduced as an instrument mainly to create economic spread effects Black Reserves in the mid-fifties and early sixties (South Africa, 1956; and Verwoerd, 1960). The Central Authorities retained this interpretation of the concept of 'growth points' up to the early eighties (South Africa, 1975; and 1981) when they introduced the concept of an integrated regional development approach in 1982. Now, in addition to their function as employment centres the 'growth points' (which now have become 'industrial development

points' and 'deconcentration points') also have to serve as counter-weights for the metropolitan areas in peripheral areas and as centres to accommodate industrial deconcentration in metropolitan areas (South Africa, 1985: 14,16). All the designated deconcentration points are located within 'border areas' of Black Reserves, however, while other possible deconcentration points with obvious potential in and around the metropolitan areas have been overlooked. This automatically gives the deconcentration points a political connotation. The association of the development centre concept with the development of Black Reserves and with apartheid, has over the years shrouded the concept in a cloud of negativism (Anon., 1973). A shift in emphasis away from industrial development in outer peripheral areas (Browett, 1976:20; Fair, 1982:51; Geyer, *et al.*, 1988:329) to industrial development in the major and intermediate size centres in South Africa seems necessary at present (Geyer, 1987:282-283, 1988:160). That implies a shift in emphasis away from the concept of 'induced' development centres to the concept of 'natural' or 'spontaneous' development centres (Parr, 1973:173-174; Hansen, 1978(b):545).

If this is true, an inner metropolitan industrial deconcentration policy for South Africa (as part of a comprehensive reassessment of the country's urban development policy) automatically becomes a priority. There is, therefore, an apparent need for a thorough reassessment of the present metropolitan spatial frameworks (South Africa, 1980, 1981, 1981A) in South Africa. Additional centres are needed in the metropolitan and megalopolitan areas to serve as industrial and commercial deconcentration points. The economic potential map may prove to be a potentially useful aid in the formulation of metropolitan deconcentration policy in the country.

In view of the foregoing exposition it is the purpose of this paper:

- to present a method for measuring inner and intermetropolitan economic potential levels in South Africa. The PWV area is used as an example[2],
- to give a visual representation of such relative economic potential levels, and
- to indicate possible general applications of this economic potential model as an aid in the formulation of more flexible geo-economic deconcentration strategies for major metropolitan areas.

2. MEASUREMENT OF METROPOLITAN ECONOMIC POTENTIAL

Some indications of possible criteria which can be used to determine inner (in the case of metropolitan areas) and inter-metropolitan (in the case of megalopolitan areas) economic potential levels are to be found in the definitions of what is generally known as the development axis.

Friedmann (1966:xv) defines the development axis as a growing region in which the intensity of development tends to be directly proportional to the 'economies' of the development centres on either side of the region (which is interpreted as the magnitude of the agglomeration economies of the centres) and inversely proportional to the distance separating it. There is an obvious similarity between his definition of an axis and Newton's law of gravity. Usually a development axis comes into being when the mutual interaction between two interrelated development centres along a communication axis creates a favourable milieu for the conducting of further economic activity at, and in the vicinity of, such a communication axis.

In his definition of the concept, Tuppen (1977:3), like Gruber (1976:45), stresses physical movement along the axis centres as a criterion of the mutual dependency of the two centres. According to Koch (1976:186) population densities may be a possible criterion, while Von Papp (1976:83) regards development centres with an above average population growth rate as a prerequisite for the establishment of a development axis.

Based on the foregoing, it was decided that a method should be found to reflect the relative weight of, or force of attraction exerted by a development centre in relation to others in a particular area, and to use such a weight variable as an indication of relative economic potential differences of centres in geographical space, thus linking the concepts of geographical and economic space. It goes without saying that such variables should reflect as many as possible of those characteristics of a development centre which lead to its relative force of attraction in relation to that of other similar centres in an area.

Founded on the principles of the law of gravity, theorists like Reilly (1953), Janelle (1969), Stewart (1947), Harris (1954), Clark (1966) and Richardson (1974) have made valuable contributions in the related fields of gravity and potential models. Gravity and potential models – both part of the body of spatial interaction theory – can directly or indirectly be linked to the concept of intermetropolitan economic space.

In his well-known work of 1953, Reilly indicated that under normal conditions, the influence of forces of attraction of two cities on an intermediate town is approximately in direct proportion to the populations of the two cities and in inverse proportion to the squares of the distances of these two cities from the intermediate town (Murphy, 1966:61).

The 'link-demand', which resembles the relative magnitude or vitality of the interaction between a number of cities was determined by Janelle (1969: 360). He divided the product of the urban populations of alternate pairs of cities (which to his reasoning resembles the magnitude of each city as a source of interaction) by the square of the distance between each pair, the sum of which represents the "link-demand" of that particular link connecting all alternate pairs of cities which make use of the specific link.

Steward (1947:471:480) also used population figures to determine what he called the 'population potential' of the United States, Japan, Europe and Africa. Each geographical area was arbitrarily subdivided into smaller geographical units with an arbitrarily chosen nodal point for each unit. Based on the gravitational principle, he subsequently determined the population potential, using this arbitrary information.

Criticism against these attempts by Reilly (1953), Janelle (1969) and Steward (1947) to quantitatively express economic spatial dynamics between development centres is rather general. Firstly, arbitrary methods are applied which complicate comparative

studies in other areas. Secondly, the criteria which were used do not reflect a wide enough spectrum of urban agglomeration economies. Differences occur in the structure of the population of cities (or regions) in terms of their composition, levels of development, employment, and per capita income, especially in South Africa. Urban population size is therefore a questionable criterion if it is used as the only indicator of the relative 'weight' of a development centre in a gravitation related context, without supplementary substantiating criteria such as their economic sectoral composition, their employment structure, income levels of the population, etc.

The pioneering work of Steward was subsequently continued by theorists such as Harris (1954), Clark (1966), and Clark, Wilson and Bradley (1969), who developed potential models to determine the market potentials for different regions in terms of their accessibility. In his review of the application of the concept, Richardson (1974:325-326) argues that the economic potential model, as applied, generally allows for greater balance between the 'weight' of nodes and internodal spatial friction than does the unchanged gravity formula. However, he suggests a broadening of the weight variable in the potential model by substituting income and population variables by agglomeration economies. He views agglomeration economies as a function of scale whose range is reduced by friction of space.

Richardson (1974:326) also touches on a relevant and thus far unsolved problem regarding the potential and gravity model concepts, namely that of suitable variables to express the multidimensional nature of both agglomeration economies and economic distance measures. He also differentiates between what can be called 'social' and 'economic' agglomeration forces: the former embrace household and social amenities and may also include pleasant environmental and working conditions, while the latter are commercial and industrial agglomeration forces (Richardson, 1977:182-183).

Various attempts have been made to find a suitable means of measuring agglomeration economies. Marcus (1965: 281) expresses agglomeration economies in terms of the growth of a particular type of industry in an area proportional to the growth of the same type of industry nationally. This method is criticised by Richardson (1977:197) as being little more than a determination of local advantages for a certain industry in an area. According to Carlino (1982:96) factors other than those associated with agglomeration economies can equally well lead to an above average growth performance. As a method to measure agglomeration economies in metropolitan areas, it lacks aggregate qualities, because only industrial growth is being looked at in Marcus' method. Agglomeration economies entail more than just external economies for industries. They also include commercial and social agglomeration economies.

Another way of determining agglomeration economies is the production function method applied by Sveikauskas (1975), Segal (1976), Carlino (1979 & 1982) and Moomaw (1983) in various ways. Although it has a firm theoretical footing, the function which relates a firm's output to its inputs is also not comprehensive enough to encompass the wider range of agglomeration properties of cities. More than increasing returns of firms in terms of factor productivity (Thirlwall, 1974: 40-47), is of importance in the determination of agglomeration economies of centres in this study.

Three types of industrial agglomeration economies can be distinguished (Glasson, 1983:175-179); economies internal to the firm, economies external to the firm, but internal to the urban area. The latter are known as 'urbanisation economies'. The production function method may be a potentially useful mechanism to measure the former two types of agglomeration economies, but in this study we are interested in 'urbanisation economies'.

3. AN ECONOMIC POTENTIAL MODEL

According to Mayer (1969:9) ". . . the attraction of any given city, and hence its growth, is dependent upon not only its own mass – the demands of its own population – but also its interaction with every other establishment outside the city with which it interacts. The importance of such interactions, along routes of transportation and communication, may also be measured in terms of the total attractiveness (mass) of each of these external places (establishment clusters) and inversely as the distance of each in turn from the city. The latter, an extension of the gravity model, is called the potential model . . . ":

In view of this generally accepted relation between the 'weight' (or agglomeration potential) of development centres, their distances apart and communication between them, and in view of the criticisms expressed earlier, it was decided to devise an economic potential formula which would directly and indirectly give expression to a wider spectrum of agglomeration properties than those criteria used by theorists like Clark, Marcus and Carlino.

Paradoxically, a criterion based on urban population size seems to be inevitable. Population size, according to Carlino (1982:97) " . . . intermingles a number of broadly different agglomeration forces". It is those very aggregative properties which make it such a promising criterion as a point of departure. It must, however, immediately be stressed that urban population size alone would by no means be a sufficient criterion.

Due to differences in the availability of factors of production in geographic space – this may include the availability of raw materials, the availability of capital, differences in the quality of labour and in entrepreneurial skills – and consequently the price of factors of production, cities of approximately equal population size may have greatly differing economic production capacities, especially in developing countries. This in turn, may lead to differences in the availability of commercial and industrial agglomeration economies in such cities. The gross domestic (geographical) product (GGP) seems to be a promising qualitative measure to be combined with the population parameter, because it not only enables one to differentiate between the relative productive capacities of the urban communities, but it also makes an identification of leading economic sectors as well as a comparison of the relative economic performance of different economic sectors possible.

The GGP is an enumeration of the magnitude of production activity and, therefore, the total money value of production generated by production factors over a specific period of time

within a specific area. It is a yardstick of the economic performance of a geographical unit, which contains all those economic factors determining the availability of commercial and industrial agglomeration economies in that unit. The population size, therefore, represents *inter alia* the magnitude of an area's 'human potential' or social oriented agglomeration forces which, as mentioned above may include factors such as the availability of work in a pleasant environment, but may also include aspects such as the availability of certain social amenities in a specific area *or* pleasant climatic conditions, etc. The GGP on the other hand reflects the magnitude of production of that area as a result of the combination of human, economic, and natural resources (which includes the exploitation of 'urban economies') in the production process.

Together with these two basic components, the following combination of criteria was chosen to express the magnitude of agglomeration forces exerted by development centres:

$$IEPI_A = \frac{P_A^g \, GGP_{DA\,(se)}^g}{P_{DA}^g \, GGP_{DA}^g} \Big/ \frac{P_{Nu}^g \, GGP_{N\,(se)}^g}{P_N^g \, GGP_N^g} + \frac{P_{Ae} P_{Ae\,(i)}}{P_{Ana}} \Big/ \frac{P_{Ne} P_{Ne\,(i)}}{P_{Nna}} + \frac{P_{Ae\,(se)}}{P_{Ae}} \Big/ \frac{P_{Ne\,(se)\,(i)}}{P_{Ne}}$$

Where $IEPI_A$ = inherent economic potential index of development centre A; A = 1, . . . ,n;
P_A = population of A;
P_D = population of the district of A;
P_{Ae} = economically active population of A;
P_{Ana} = economically non-active population of A;
$P_{Ae\,(i)}$ = median income of economically active population of A;
P_{Nu} = national urban population;
P_N = total national population;
P_{Ne} = economically active national population;
P_{Nna} = economically non-active national population;
$P_{Ne\,(i)}$ = median income of economically active national population;
$P_{Ne\,(se)}$ = selected part of economically active national population (agriculture excluded)
$P_{Ae\,(sc)}$ = selected part of economically active population of A (agriculture excluded);
$GGP_{DA\,(se)}$ = selected sectors of the gross geographical product (GGP) of the district of A (agriculture excluded);
$GGP_{N\,(se)}$ = selected sectors of the national GGP (agriculture excluded);
GGP_N = national GGP;
GGP_D = GGP of the district of A;
g = growth rate of variable over period of time.

It is obvious that the IEPI formula has a number of built-in qualitative and quantitative criteria. The first term[3] of the formula combines the population and the GGP of 'urban oriented firms'[4] of a development centre (together with its growth over a period of time) with the total population and GGP of the magisterial district in which it is located (together with its growth over the same period of time). The population is an indicator of broadly different social and household agglomeration forces (Richardson, 1977:182-183; Carlino, 1979:365 & 1982:96). As discussed earlier, the GGP is a measure of business and industrial agglomeration economies associated with indivisibilities in use of factors of production (Hirschman, 1972:75; Carlino, 1979:366). It is contended here that the availability of agglomeration economies in a city and the degree to which they are being exploited up to a certain point in time by the population of the city are reflected in the GGP of that particular year for that particular city. Such a combination of variables in the first term of the IEPI formula does not only express the relative magnitude of market and non-market oriented agglomeration economies in an aggregated manner, but it also has the additional advantage of serving as an indication of the relative urban versus regional dominance of a case in hand. While this is a 'static' model, the 'dynamic attributes' of each individual case are represented by the growth factor which is added as an exponent to each variable in the first term. The exponent will add weight to rapidly growing centres and *vice versa.*

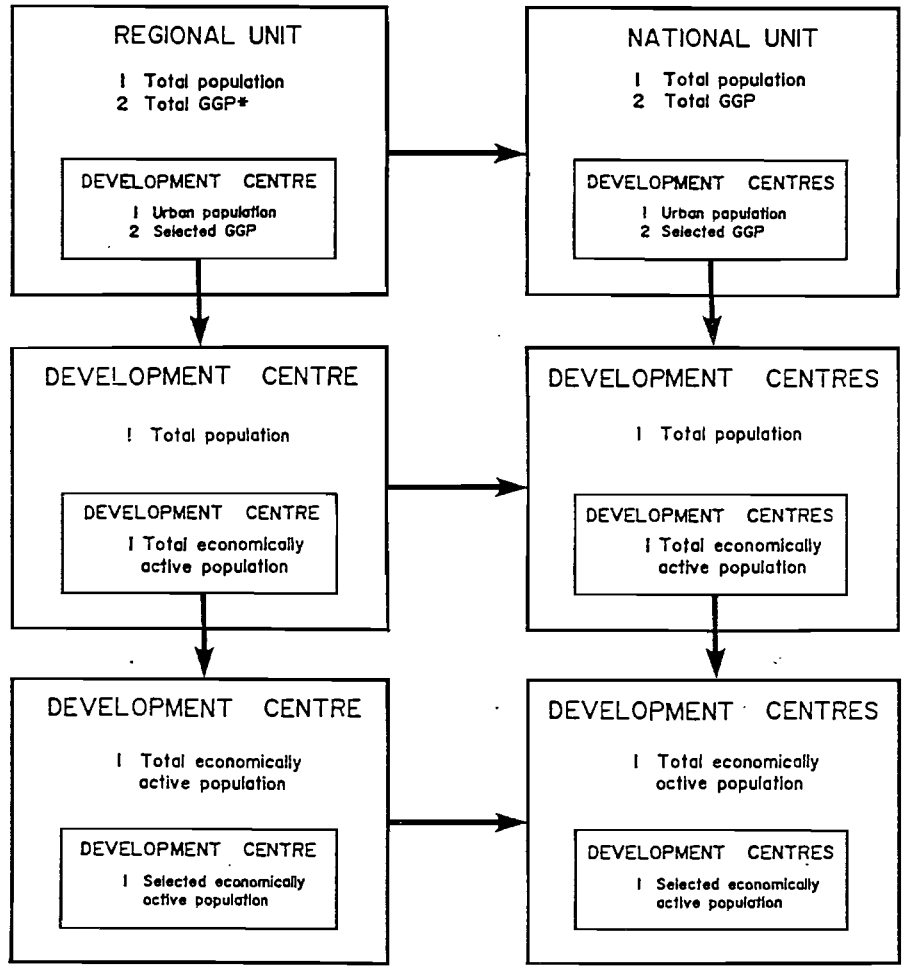
The second term[5] is incorporated in the formula as a control measure of the first term, to obviate the problem of possible (and likely) differences that might occur in the economic qualities of communities. This term serves as an indicator of the relative dependency rate combined with a median income parameter. Two urban societies of approximately the same size and magnitude of total economic performance may differ greatly from one another in terms of its dependency rate and median income, especially in South Africa with its heavily regulated and developing dualistic economy. This may be due to numerous factors such as large scale mining activity in a centre where a relatively small group of people is actively engaged in the mining activities, with relatively little financial benefits accruing to a large proportion of the community.

The third term[6] serves as an additional control measure of the first. It might under normal circumstances and especially in the case of bigger cities, where very large majorities of economically

active people are engaged in urban oriented economic activities, appear to be little more than a duplication of the second term. It was, however, included for the following reason. The second factor[7] of the first term of the formula makes it possible to determine the potential index of a development centre, not only in terms of all non-agricultural (or urban oriented) economic activities, but also in terms of a specific economic sector, and even in terms of a certain component of a specific economic sector. In such cases the second term alone would be inadequate as a control measure because it does not differentiate between economic sectors. The third term does make such a differentiation possible and is thus imperative. In addition, there is a possibility that small agriculturally oriented towns might occur in the study area, where the proportion of the number of economically active people, relative to the total number of economically active people, is likely to be high. Such towns might have to be compared with cities where relatively few people are expected to be engaged in agricultural activities. It is the function of the third term, as a control measure, to highlight such cases.

In each term the parameters for the different development centres are compared with the corresponding figures for the country as a whole. Cities for which the result of each term is greater than one, or for which the result of all three terms is greater than three can be expected to have 'development centre properties' and *vice versa*. In conclusion, the reason behind the composition of formula (1) is diagrammatically illustrated in Figure 1.

FIGURE 1 A DIAGRAMMATIC REPRESENTATION OF THE COMPOSITION OF THE IEPI FORMULA



* GGP = Gross geographical product

The result of an application of the IEPI formula serves as an introspective indication of the magnitude of the realised economic potential of a particular centre within a metropolitan area at a certain point in time, yet it does not take external influences – i.e. of one centre upon another in an open economic society – into consideration. In an open economic society – even in South Africa, despite the enforcement of certain restrictive legislation by the government – it is fair to expect that, in time, all centres will interact with one another. It can also be expected that a centre's influence on the potential of all other centres in the community would, in terms of its 'weight' and distance from the other centres, be in accordance with the gravitation principle. This external influence was taken in account by the incorporation of the IEPI in the potential energy formula (Richard et al., 1966):

$$TEPI_a = q_a \quad (q_i / r_i) \qquad (2)$$

where

$TEPI_a$ = total economic potential of development centre a;

q_a = inherent economic potential index (IEPI) of a;

q_i = IEPI of development centre i; i – 1, ... ,n;

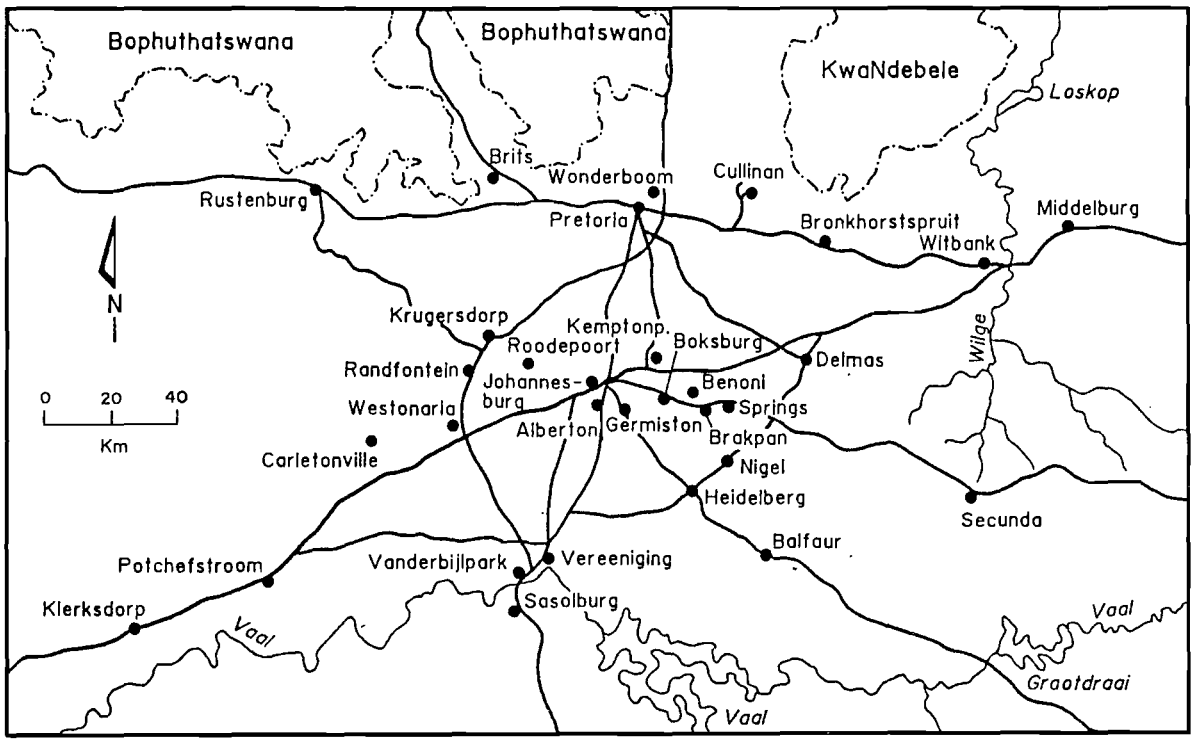
r_i = geometrical distance of i from a.

The TEPI values for a specific area could differ greatly which would make direct interpretation of the data difficult. To avoid this problem it is suggested that the TEPI values of all centres in an area be expressed as percentages of the centre with the highest TEPI. If the exercise is repeated for the area at a later date, as a means to assess the results of a particular development policy over the medium *or* long term, the TEPI values of consecutive studies can still be expressed as percentages of the highest TEPI value in the first study.

4. APPLICATION TO THE PWV

The Pretoria-Witwatersrand-Vaal Triangle area and a selection of surrounding cities[8] (figure 2) were chosen as an example to test the applicability of the inherent and total economic potential index formulae. The inherent and total economic potential indices of all the centres included in the case study were calculated and are tabulated in Table 1. Growth exponents were not used in this exercise due to statistical discrepancies in the census data. Changes in district boundaries and in definition of what is being regarded as urban and non-

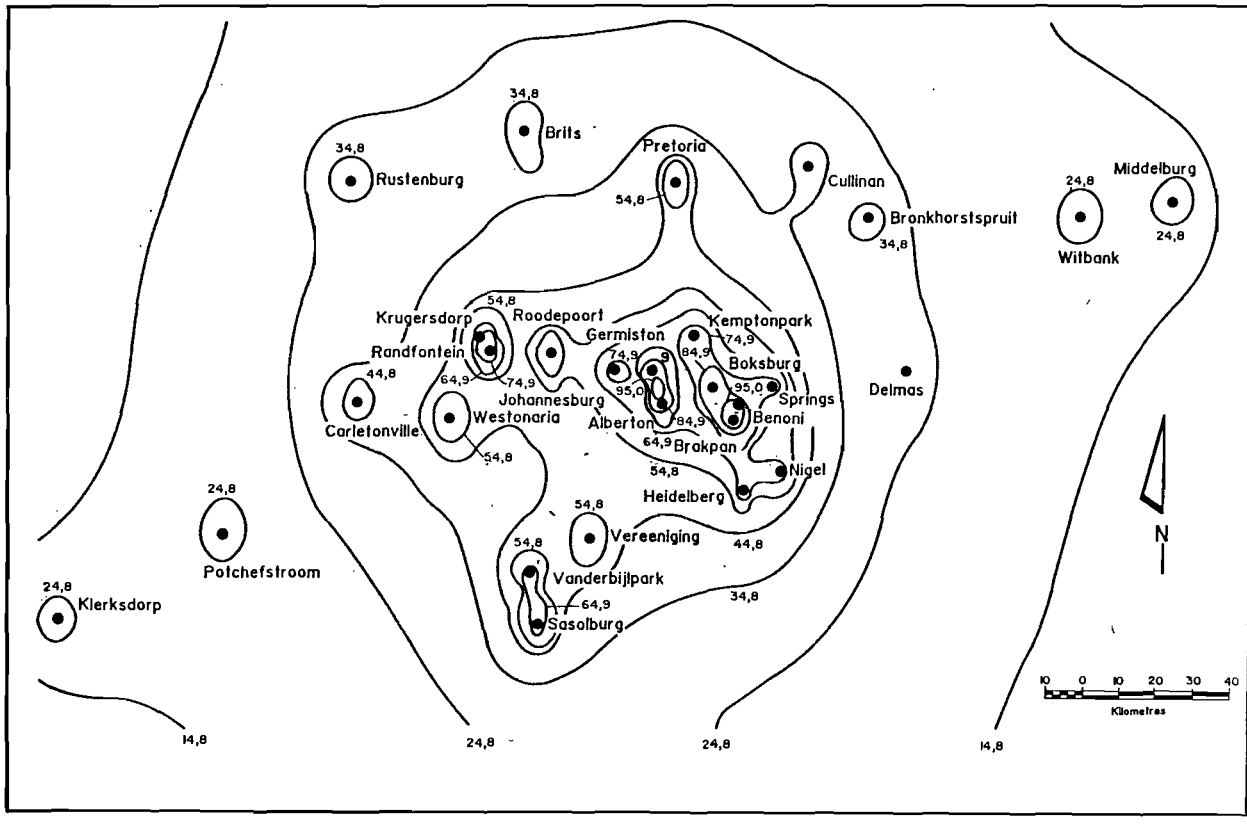
FIGURE 2 STUDY AREA



urban population within such districts between census years have led to unexplicable differences in data for certain centres and to unrealistic growth rates for others.

The map showing isopotential lines of equal TEPI values for the study area is shown in Figure 3. Relative comparative economic potential levels of the different centres within the urban complex and of the areas in between can be deduced from this figure. Figure 3 is an example of the way in which centres differing considerably from one another in size, composition, and location can now be compared. In order to be able to draw such isopotential lines of equal TEPI values, the following

FIGURE 3 ISOPOTENTIAL LINES OF TOTAL ECONOMIC POTENTIAL OF THE PWV AREA



procedure was followed:

Firstly, the coordinates of every centre were determined on an arbitrary scale. Secondly, a grid with $(m^+ 1)(k^+ 1)$ intercepting points was formed on the same arbitrary scale by the subdivision of the area into m horizontal and k vertical zones. TEPI values were calculated for each of these points by means of formula (2). The IEPI-value (q_a) of each coordinate on the grid which does not coincide with a centre was arbitrarily taken as 1, while the geometrical distance (straight line) r_i from a given point j with coordinates (x_j, y_j) to point i with coordinates (x_i, y_i) was given by:

$$r_i = \sqrt{(x_i - x_j)^2 + (y_i - y_j)^2}$$

TEPI values of coordinates on the grid which coincide with each of the n centres were omitted. The reason for the omission was because the actual IEPI values of the centres (cf. Table 1) are not comparable with the arbitrary IEPI values chosen for the other points on the grid. If the actual TEPI values of centres were to be retained on the grid, one term of formula (2) would become infinite because r_i would then be equal to zero which is unrealistic.

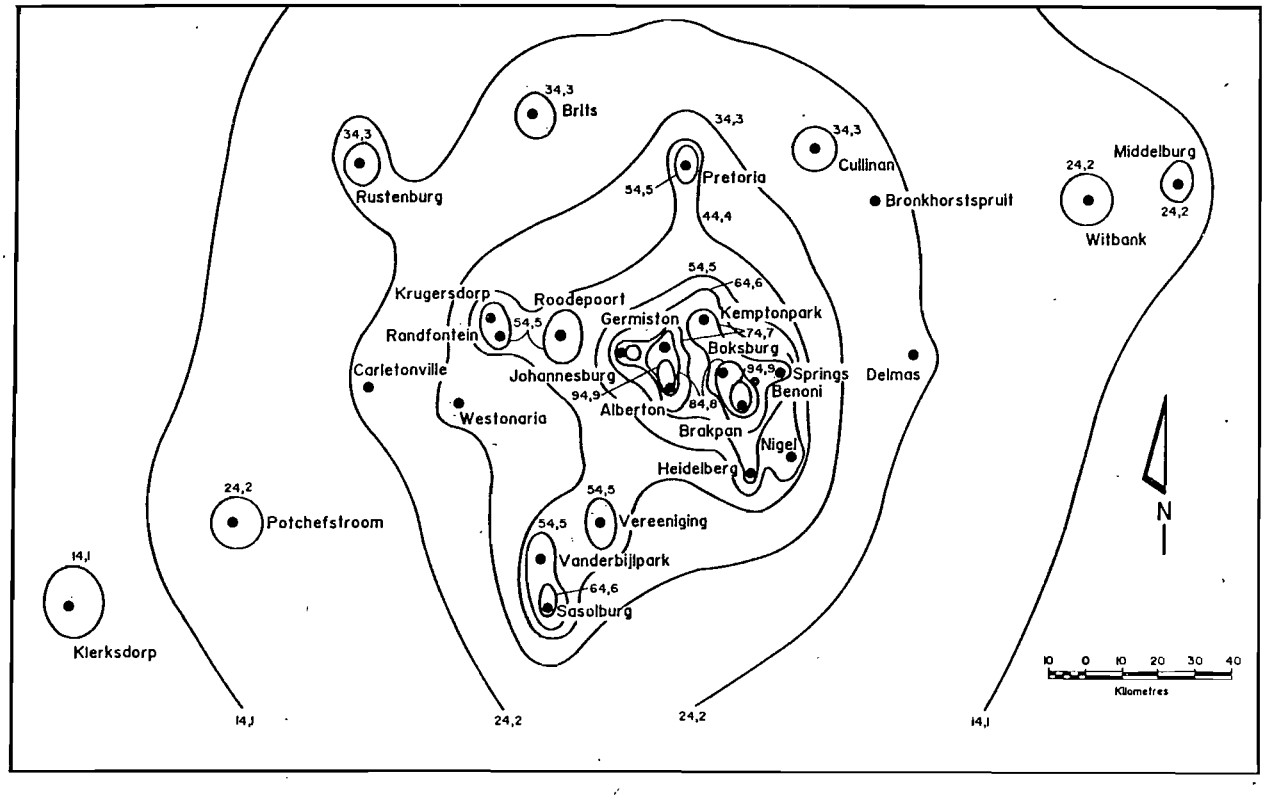
Although it might be possible to alter the results of formulae (1) and (2) by the introduction of constants, one is hesitant to do so. As was reasoned above, all the terms in formula 1 are of equal importance in the determination of the agglomeration potential of centres, and therefore, equal weights for the three terms were regarded as being appropriate. In case of formula (2) a constant would only have an absolute and no relative effect on the results, and in terms of the index values is meaningless, and therefore unnecessary.

5. GENERAL APPLICATIONS OF TEPI MAPS IN DEVELOPMENT PLANNING

As a quantitative representation of the economic potential of development centres in visual terms, which otherwise may differ greatly from one another in terms of their compositions and economic bases, the economic potential map makes possible a quantitative differentiation between such centres in terms of their comparative economic superiority or inferiority for development planning purposes.

These maps also have an additional advantage. The criteria which are used in the first and third term of formula (1) can be changed, creating the possibility of differentiating between development centres in terms of different economic sectors, and therefore, allowing for more flexibility in the degree of disaggregation of the development properties of centres. The mining sector (or any other economic sector) can be excluded from formula 1, for example, to assess that particular sector's effect on the development potential of centres as compared to the remaining economic sectors. This possibility is demonstrated in Figure 4, where the exercise was repeated for the PWV area, but without the mining sector.

FIGURE 4 ISOPOTENTIAL LINES OF TOTAL ECONOMIC POTENTIAL OF THE PWV AREA (Mining excluded)



By means of the interpretation of the distances between economic potential lines between centres and the levels of such lines, it is possible to visualise the relative dominance of any one of such centres on the area between them. It can be seen in Figure 3 that in the case of Krugersdorp-Randfontein as opposed to Roodepoort as well as in the case of Benoni-Brakpan as opposed to Heidelberg-Nigel, the former exert a greater influence on the areas between them in both cases than the latter.

The succession of potential lines as well as the manner in which they are curved between centres on potential maps can also serve as an indicator of

the measure of development axis formation. The distortion of the isopotential lines between centres relative to those around it may serve as a justification, for example, of the amount of economic stimulation that should be given to an existing or potential industrial centre, or to justify investment in transportation and communication infrastructure on the axis. This enables the decision-maker to determine a priority scale and time schedule for investment to stimulate economic development (in deconcentration points for example) in and between metropolitan areas.

The real extent of different levels of economic potential also serves as an indicator of where a regional development authority could expect a higher return on its investment capital and *vice versa*, which would allow it some flexibility in its development policy options. In recessionary economic circumstances a larger proportion of social overhead capital for industrial deconcentration may be provided at deconcentration points in areas of relative greater economic potential with a higher expected rate of return on investment. This higher return on investment capital can then be directed to 'directly productive activities' (Hirschman, 1972) at decentralization points and to grassroots development in peripheral areas (Geyer, *et al*, 1988: 329) – i.e. areas of lower economic potential levels. It is clear, therefore that the EPI map is a potentially useful instrument in the formulation of both physical and economic development policy in the decision-making process.

The economic potential map has one obvious and very distinct applicational limitation. This limitation is inherent to all spatial potential models, however. It gives a quantitative representation of the economic potential of a centre at a specific time, based on factors which directly influence the centre's economic potential, but obviously does not take cognizance of all factors which influence development planning decisions. Factors such as political and administrative obstacles which directly or indirectly may influence the development potential of a centre as a nodal point in a field of economic forces are not reflected in such a map. Additional research on all economic, social and political factors which might have an influence on the potential of a centre as a nodal point in economic and geographical space, needs to be done in order to supplement the economic potential map. This aspect is especially applicable in South Africa where rapid changes in political and economic thinking, due to internal and external pressures, may influence the relative locational and strategic advantages and disadvantages of different centres and areas.

An additional disadvantage of the economic potential map is that it does not take inherent geographical and other limitations such as inaccessible terrain into account. Such limitations need to be highlighted by supplementary maps containing relevant cadastral, geographical, and land use information.

6. CONCLUSION

A relatively simple model for determining the economic potential of metropolitan areas using aggregated population and economic criteria as surrogates for urban agglomeration economies has been presented. Other substitutes studied were found to be either too disaggregate (in the case of the production function method) or inadequate as parameters (where income or urban population figures alone were used) to include the widest possible spectrum of social, household and business agglomeration economies.

Contrary to other models where arbitrary procedures were followed, an attempt was made in this exercise to provide a method which can equally well be applied in cities differing substantially from one another in terms of development level and economic composition. The EPI model can be used to derive total EPI values for centres, which when mapped, provide a visual image of the relative levels of economic potential of development centres and their surrounding areas. As a regional planning instrument the model and its derivatives can assist the decision-maker in regional development policy formulation on regional, inter-regional and even national levels of planning.

TABLE 1: IEPI AND TEPI VALUES FOR THE PWV AND SURROUNDING CENTRES

Development centre	IEPI	TEPI	TEPI as % of highest
Alberton	3.909	38.660	73.98
Benoni	3.743	40.843	78.15
Boksburg	4.316	42.291	80.92
Brakpan	3.806	41.543	79.49
Brits	2.170	9.558	18.29
Bronkhorstspruit	1.868	7.752	14.83
Carletonville	5.337	21.477	41.10
Cullinan	2.451	10.749	20.57
Delmas	1.719	6.679	12.78
Germiston	5.714	52.261	100.00
Heidelberg	2.484	19.119	36.58
Johannesburg	3.998	32.106	61.43
Kempton Park	3.801	33.437	63.98
Klerksdorp	2.956	5.564	10.65
Krugersdorp	3.391	27.430	52.49
Middelburg	2.339	4.876	9.33
Nigel	3.780	24.935	47.71
Potchefstroom	2.633	7.309	13.99
Pretoria	3.967	20.732	39.67
Randfontein	3.572	29.419	56.29
Roodepoort	4.536	30.382	58.14
Rustenburg	3.432	11.785	22.55
Sasolburg	4.359	24.434	46.75
Springs	3.912	30.244	57.87
Vanderbijlpark	3.879	24.207	46.32
Vereeniging	3.658	22.736	43.50
Westonaria	5.425	30.243	55.87
Witbank	3.046	7.293	13.95

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NOTES:

[1]Terms such as core region (Friedmann, 1966:XV), growth poles (Thomas, 1972), growth points (Hirschman, 1972:183), growth centres (Rodwin, 1972), development poles (Todd, 1974), and development gravity points (Von Papp, 1976) are common synonyms for the term development centre. In this paper the term development centre is used because the prefix 'development' refers to more than just economic growth. It refers to both economic sectoral growth and economic structural expansion (Myrdal, 1975:84-85). The suffix 'centre' is of significance both in terms of geographical and economic space; it combines the notion of a point in geographical space, which has position but no magnitude, with that of economic space, which has magnitude but no specific location *per se*. It bears the meaning of both a focal point of concentration and a source of economic (human) activity. Therefore, it could equally well refer to any rapidly growing urban agglomeration – a town, a city, a metropolis, or even a megalopolis – of outstanding economic significance, regardless of its size.

[2]In terms of Gottmann's (1973:4) definition of a megalopolis as a 'cluster of metropolitan areas' the PWV area can be regarded as one, and, therefore, the results of such a geo-economic model for the PWV area would reflect economic potential levels of both inner and inter-metropolitan areas.

[3]The expressions 'term' and 'factor' which follow in the rest of the discussion are used in their common mathematical context. The first term, therefore, refers to:

$$\frac{P^{g}_{A}\ GGP^{g}_{DA\,(se)}}{P^{g}_{DA}\ \ GGP^{g}_{DA}}$$

[4]These are all enterprises in the secondary, tertiary and service sectors, as well as the mining sector, which tend to support the urbanisation process and are instrumental in the formation of agglomeration economies in general.

[5]I.e.: $\frac{P_{Ae}\,P_{Ae(i)}}{P_{Ana}}$

[6]I.e.: $\frac{P_{Ae\,(se)}}{P_{Ae}}$

[7]I.e.: $GGP^{g}_{DA(se)}$

[8]All centres which previously and presently played a role in the development planning policy of the government regarding the PWV (South Africa, 1975, 1981 & 1981A) were included in the study.