# DIFFERENTIAL ECONOMIC MULTIPLIERS:

# AN EXTENSION OF WEISS AND GOODING AND AN APPLICATION TO THE EASTERN CAPE PROVINCE

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*CERTIFICATION*

I hereby declare that this thesis is entirely the product of my own work.

# *ABSTRACT*

Economic impact assessment in its most general form is concerned with the identification and evaluation of the effects of a given change in an economic system on other parts of that system. This type of assessment may equally be applied to the effects of a complex economic policy on a country or region, as to the estimation of the impacts of a new manufacturing plant on employment and income in the immediate area.

The purpose of this study is to develop a practically applicable differential multiplier model, which can be easily adapted to apply to a range of economic impact studies, and which is not constrained by the considerable data requirements of more complex models, such as the input-output model..

The model that is developed allows for a certain amount of differentiation, such as that between skilled and unskilled workers, and carries this differentiation through all stages of the multiplier process. The basic difference between the regional and the national multiplier is the existence of additional leakages from the flow of income, particularly in the form of interregional imports. This model also takes account of the leakages at every link in the production chain, thus ensuring that the multiplier works on the actual value-added generated by a new investment project. By definition, the model focuses primarily on less complex forms of impact assessment, such as a new investment project in a local sub-region

As an illustration of the manner in which such a model could be applied, it is used to estimate the impacts of a proposed zinc refinery and phosphoric acid plant project in the Eastern Cape province of South Africa.

# 1. INTRODUCTION

## 1.1 Background to the Study

Economic impact assessment in its most general form is concerned with the identification and evaluation of the effects of a given change in an economic system on other parts of that system. This type of assessment may equally be applied to the effects of a complex economic policy on a country or region, as to the estimation of the impacts of a new manufacturing plant on employment and income in the immediate area.

The purpose of this study is to develop a practically applicable differential multiplier model, which can be easily adapted to apply to a range of economic impact studies, and which is not constrained by the considerable data requirements of more complex models, such as the input-output model. By definition, the model focuses primarily on less complex forms of impact assessment, such as a new investment project in a local sub-region. An impact assessment model that is relatively cheap and easy to apply can be a powerful aid to investment planning in local regions.

## 1.2 Structure of this Report

Repercussions of changes in the level of expenditures on total income can be estimated via the concept of the multiplier. The original Keynesian income multiplier developed in macroeconomic theory has direct analogies at the regional level in the form of regional income and economic base multipliers. From a regional policy perspective, the theory of the regional multiplier in its most basic form provides a simplistic measure of the impact of autonomous increases in income on final income and/or employment in a region. As such the model aims for a final result, and shows little of the intermediate effects. More complex models, such as the input-output model, attempt to overcome this shortcoming, but at considerable cost in terms of data requirements. Chapter 1 of this paper provides a discussion of the three most common approaches to economic impact assessment, namely the economic base model, the Keynesian multiplier model and the input-output approach.

A number of modifications to the basic model have thus been implemented over the years in

an attempt to capture at least some of the intermediate effects, without the prohibitive data requirements of the more complex models. These modifications include refinement of the multiplier itself, as well as changes to the multiplicand. Weiss and Gooding (1968) extended the theory of the export base multiplier by attempting to differentiate the export base and derive differential multipliers for each distinct export sector. Their hypothesis was based on an economy consisting of identifiable export (or exogenous) sectors, each of which was linked to the local (service or endogenous) sector in a specific way. Subsequent induced changes within the service sector itself, however, were assumed to be of a uniform nature.

The Weiss and Gooding model can be usefully applied to other sectors of economic activity, such as the multiplier effects that different investment projects may have on a local economy. This is illustrated in Chapter 2, where the model is extended to show the differential impacts which may arise from a capital-intensive investment project using skilled labour, and from a labour-intensive investment project using primarily unskilled labour.

Using this extended model of the Weiss and Gooding differential multiplier as a conceptual basis, a more complex model is developed in Chapter 3. This model allows both for differentiation throughout all stages of the multiplier process, as well as capturing leakages from the flow of income at all links in the production chain, so that the multiplier is seen to act on the actual value added by any specific investment project.

The usefulness of the model is tested in Chapter 4, where it is applied to a proposed zinc refinery and associated phosphoric acid plant project in the Eastern Cape Province of South Africa. Finally, a conclusion is offered.

# 2. OVERVIEW OF THEORIES OF ECONOMIC IMPACT ASSESSMENT

## 2.1 Introduction

The derivation of the regional multiplier has developed from first attempts made by geographers and planners, which resulted in the economic base approach; through the application of Keynesian multiplier analysis, with its stronger theoretical basis; to more complex models, such as econometric models and input-output analysis, which attempt to replicate the complicated economic linkages and interactions within and between regions. While the more complex models strive to overcome the main shortcoming of the regional income and economic base multipliers - namely, that they provide only an aggregate estimate of the effects of an expenditure change, without distinguishing between the sectors in which the original expenditure change originates - and present a more accurate picture of the economy, they are often constrained by the high cost of the considerable data required for this purpose. As a result, attempts are continually being made to improve and expand the more simple forms of multiplier analysis, such as the economic base approach and the Keynesian model, in order to obtain more accurate assessments of economic impacts without the constraints of prohibitive data requirements and costs.

Presented below is a discussion of the economic base theory, the Keynesian multiplier and the input-output model as tools of assessing economic impacts. This discussion will form the backdrop to the construction of a differentiated multiplier model which will be applied to the assessment of the economic impacts of a proposed zinc refinery and related phosphoric acid plant in the Eastern Cape region of South Africa. The economic base approach provides the conceptual model for determining the manner in which different types of investment projects may have differential effects on the local economy. From this conceptual basis, a more complex and specific model is constructed using the basic Keynesian income multiplier formulation, and based on data from the area and from the proposed project.

The economic base, Keynesian and input-output approaches to economic impact analysis are not totally unrelated, but differ primarily in their focus and underlying assumptions. The economic base model estimates the indirect and induced changes in non-export (service or local) industries in a region in response to changes in identified export sectors. Economic

base theory has sometimes been considered "a very special case of input-output analysis" (Romanoff, 1974): the latter theory focuses primarily on the economic inter-relationships which govern an economy, of which the economic base model expresses only one, namely that between the export and service industries within a region (Weiss and Gooding, 1968). The input-output approach is generally considered to provide the most comprehensive measure of indirect and induced effects (McNicoll, 1981). Obvious parallels can also be drawn between the simple economic base model estimated by means of a regression equation and the Keynesian income multiplier.

## 2.2 The Economic Base Approach

The economic base approach represents the first attempt to construct a regional multiplier (Armstrong and Taylor, 1978), and has since given rise to a wide variety of multiplier models. All these models share the central proposition that regional income and employment relies heavily on a basic sector which serves exogenous (or export) demand, and in which the income generated is derived largely from external sources. Correspondingly, a nonbasic sector also exists to serve endogenous or local demand. The nonbasic (or "service") sector depends for its level of economic activity on the local respending of basic income.

Following Armstrong and Taylor (1978), the structural equations for the model can be represented as follows:

(2.1) $T = S + B$

(2.2) $S = sT$

where T represents total regional income; S is income generated by the nonbasic sector; B is income generated by the basic sector; and s is a positive fraction. From the above equations we obtain

(2.3) $T = \frac{1}{(1-s)} B$

with $\frac{1}{(1-s)}$ representing the "base" multiplier.

As Weiss and Gooding (1968) note, this simple form of the multiplier can be improved if data for two or more time periods are available, allowing for the application of a regression equation. In this case, the underlying structural equations will be:

(2.4) $T = S + B$

(2.5) $S = a + hT$

or

(2.6) $S = a + hS + hB$

where T, S and B are as defined above; and a is the intercept.

From the above equations we can obtain a regression equation of the form:

(2.7) $T = q + kB + u$

where the regression coefficient k is the multiplier estimate, u is a stochastic disturbance term and q is a constant. In the above equation, however, T is regressed on a large part of itself, resulting in an artificially high $r^2$ value. In order to overcome this problem, an alternative form of the equation may be used to give:

(2.8) $S = q + kB + u$

where $(1 + k)$ is the multiplier from export to total income.

The economic base model suffers, however, from a number of fundamental weaknesses, both conceptually and in terms of its application. In practice, difficulties are encountered in classifying economic activity as basic or nonbasic. Henry and Nyankori (1981:449) suggest that the bifurcation problem "is relevant to the testing of the explanatory power of the simple economic base theory, since the values of the dependent and independent variables are defined by estimates of basic and nonbasic [activity]". The practical difficulties encountered in trying to divide a region's economy into export and service activities have a number of

theoretical implications. In particular, in the continuing debate as to whether the economic base model represents a theory of long-run growth and development, or of short run economic fluctuations[1], Gerking and Isserman (1981: 452) have shown that the bifurcation method used to divide total activity into basic and non-basic activity can play a major role in determining whether empirical estimates support the long- or short-run hypothesis.

In addition, the timing of impacts and the lagged relationships between basic and nonbasic activity are likely to be affected by factors such as the region's productive capacity relative to demand, the industrial composition of the changes in basic activity, and the responsiveness of migration and labour force participation to employment and wage changes. Merrifield (1987) points out that the assumption of the economic base model that the basic-nonbasic ratio is constant in equilibrium suggests a lack of supply side constraints, and presupposes a situation in which productive factors are available in unlimited quantities at constant prices. He suggests that this assumption would seem reasonable only in small regions able to attract large stocks of resources. Both Merrifield and Frey (1989) attempt to cater for supply side factors. Merrifield (1987:284) adopts a neo-classical approach in developing a "static general equilibrium model of a largely open economy with some supply side constraints", while Frey adopts a structural approach to show how the formulation of the demand-driven economic base multiplier can be modified to allow for inelasticity in one factor of production. While a more in-depth discussion on the effects of assuming away supply side constraints is beyond the scope of this paper, the point should be made that, for purposes of accuracy, the supply side constraints of the region under study must be taken into account, albeit at a practical rather than a theoretical level.

Further shortcomings of the economic base model stem primarily from the model's neglect of economic linkages and interactions, other than that between the export sector and a homogeneous service sector. Weiss and Gooding (1968) observe that the simple economic base formulation disregards differences in the degree of inter-industry linkages among local industries, and ignores the fact that the nonbasic sector may be affected by factors other than the change in autonomous regional income. For example, regions may grow as a result of

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[1] Amongst others, McNulty (1977), Richardson (1978) and Giarratani and McNelis (1980), have argued that short-run basic linkages do not exist. These studies imply that most applications of the economic base model may be mistaken in their orientation to the short run. Further studies by both Henry and Nyankori (1981) and Gerking and Isserman (1981), however, have shown evidence of empirical and methodological shortcomings in research aimed at disproving the existence of the short run economic base multiplier. The ultimate conclusion appears to be that empirical evidence *does not contradict* the existence of the short-run economic base model.

increases in factor productivity resulting from technological innovation; or as a result of investment undertaken by entrepreneurs who expect an (autonomous) increase in local or intra-regional demand for their goods and services.

North (1955) initiated the controversy surrounding the relative contributions made by external demand factors and intra-regional growth variables to the economic growth of a region by suggesting that expansion in local activities constitutes investment which is induced by a long-run expansion in the export base. North based his hypothesis on the argument that local activities were dependent on regional income, which was in turn a function of income levels outside the region. Tiebout (1956) countered with the proposal that growth in the export base of a region is dependant on the ability to produce at relatively low cost, which is in turn linked to the ability to utilise resources in the local economy. Regional economic growth, however can be assumed to be initiated by a variety of factors, which may be demand or cost-oriented, and may be located within or outside of the region. Since the value of the multiplier is reduced the greater is the magnitude of leakages such as imports from outside the region, the size of the region, its spatial location in comparison to other regions, and the diversity of its production relative to other regions will all affect the magnitude of the economic base multiplier, and the corresponding growth in regional income.

The assumption of homogeneity within the basic sector is also problematic. The differentiated economic base multiplier model developed by Weiss and Gooding (1968) attempts to overcome this problem by disaggregating the basic sector and allowing for the differential impacts that each of these basic industries may have on the service sector. The authors, however, make no attempt to address the possibility of differential effects within a more diversified service sector. McNicoll (1981) further notes that the economic base method does not allow for the possibility of interaction among the basic industries themselves, or of feedback effects from the service sector which may lead to an expansion of secondary income in the basic sector.

Despite the apparent shortcomings of the economic base approach to economic impact analysis, the model nevertheless remains popular, mainly as a result of its relative simplicity in application (Romanoff, 1974). Weiss and Gooding (1968, p.235) support the relevance of

economic base analysis by stating that "in a national economy with a high degree of regional specialisation, the income level or growth of a particular region is dependent on its ability to export goods and services to other regions." Furthermore, because the importance of exports to an economy is generally an inverse function of its size, the limitations of using the economic base multiplier will be least significant when dealing with small regions. This is because in a small region with a market dependence on exports, other sources of autonomous growth will be relatively unimportant; local inter industry linkages will be less significant; and import-substitution prospects limited (Weiss and Gooding, 1968). Perhaps most importantly, in studies of smaller regions it is also easier to adjust for particular local circumstances, including supply side factors, and thus strengthen interpretation of the results.

## 2.3 The Keynesian Regional Multiplier

The stronger theoretical basis of the Keynesian income multiplier is often a reason for its preferred use over the economic base multiplier. The Keynesian income multiplier is probably the most well known method of economic impact analysis (Armstrong and Taylor, 1978; Sinclair and Sutcliffe, 1982) and has frequently been used in empirical studies carried out at regional and sub-regional levels of analysis (Sinclair and Sutcliffe, 1982).

The Keynesian regional multiplier can be derived from the simplest open-economy version of the Keynesian model. The principle behind this model is that a money injection into an economic system will cause an increase in the income level of that system by some multiple of the initial injection; that is:

$$(2.9) \quad Y_r = k_r J$$

where $Y_r$ represents the change in the level of the region's income; $k_r$ is the value for the regional multiplier; and J is the injection.

Regional income can be defined as the sum of consumption spending, investment, government expenditure and net exports (that is, exports minus imports) where these terms refer to the region only, and not to the entire nation. The conventional formulation of the

multiplier assumes that both consumption spending and imports of consumption goods are a function of disposable income[2], which is defined as total income less direct taxes. The level of investment, government expenditure and regional exports are assumed to be constant and autonomous. This model can be represented mathematically as follows:

(2.10) $Y_r = C + I_0 + G_0 + (X_0 - M)$

(2.11) $C = C_0 + cY_d$

(2.12) $M = M_0 + mY_d$

(2.13) $Y_d = Y - tY$

where C equals regional consumption; $C_0$ is autonomous consumption; c is the marginal propensity to consume; $I_0$ equals autonomous regional investment expenditure; $G_0$ is autonomous government expenditure within the region; $X_0$ is autonomous regional exports; M shows regional imports of consumption goods; $M_0$ represents autonomous imports of consumption goods; m is the marginal propensity to import consumption goods; $Y_d$ is disposable income in the region; and t is the rate of income tax (assumed fixed)

By substituting equations (1.11), (1.12) and (1.13) into equation (1.10) we obtain:

(2.14) $Y_r = k(C_0 + I_0 + G_0 + X_0 - M_0)$

where

(2.15) $$k = \frac{1}{1-(1-t)(c-m)}$$

Equation (1.15) is the simplest form of the Keynesian regional multiplier. A more realistic model of the regional economy would yield a more complex, and more accurate, multiplier. As is the case for the economic base multiplier, for any given region the actual value of the Keynesian multiplier will be affected by factors that influence the values of the various leakages, for example the size and location of the region, its industrial structure and the

[2]It can be argued that imports should be represented as a function of consumption, and not of disposable income (Armstrong and Taylor, 1968).

social characteristics of its inhabitants.

The crucial variable affecting the value of the multiplier is the import leakage, as represented by the marginal propensity to consume locally produced goods (c-m in equation (1.15)). An obvious implication of the importance of import leakages to the value of the multiplier, is that as the size of the region increases, the marginal propensity to consume locally produced goods, and thus the value of the multiplier, is likely to rise. Larger regions will generally have a larger production base, and will consequently have less need to import goods and services from other regions. A larger production base also implies an industrial structure characterised by a larger manufacturing sector, which suggests a reduced need for importation of manufactured goods. In addition, it implies a greater degree of interregional trade, and consequent feedback effects from this.

By the same token, the degree of remoteness of a region will affect its multiplier, causing the value to be relatively greater in more isolated regions because of their lower import leakages. The pattern of ownership and control of organisations within the region is also likely to be determined by the size of the region. In a smaller region, ownership is more likely to lie outside the area, and firms are more likely to be represented by agents. This has implications for the multiplier in terms of the extent to which profits remain within the region.

A number of modifications to the multiplicand have been developed in order to render the multiplier model as a whole more accurate. Brownrigg (1971) notes that the initial injection itself may be subject to leakages before undergoing a multiplied expansion. If the capital goods industries of the region are little developed, so that a significant leakage occurs from the initial injection in the form of directly imported capital goods required for the project, it is conceivable that the only part of the initial injection to actually pass through the multiplier would be the wages and salaries of the workers employed.

Brownrigg further suggests that the nature of the initial injection (or investment project) will have an effect on the value and formulation of the multiplier model. In general, the initial injection can be seen to have two elements. Firstly, a construction element, which represents a "once-off" injection which is not repeated in subsequent periods; and secondly, a

"permanent" or wages element representing the continuing flow of income arising from the employment provided by the project responsible for the initial injection. It is clear that under this scenario the injection leakages referred to above should be applied only to the first component, as will be illustrated in the model presented in the following chapter.

Sinclair and Sutcliffe (1982) do not believe that the Keynesian multiplier as defined here can be usefully applied to regional and sub-regional levels of analysis. They suggest that the relationship between the definition of income used and the precise nature of the change in the injections and withdrawals is of crucial importance to the accuracy of the multiplier estimate. In addition, they emphasise the need to estimate the first and second rounds of the multiplier process separately[3].

According to Sinclair and Sutcliffe, first round withdrawals are frequently atypical, and depend both upon the definition of income being used (that is, gross geographic product or disposable income of the area, measured in terms of factor prices or market prices) and on the nature of the original change in the multiplicand. For this reason, the first round propensities should be specifically estimated and should not be assumed to be equal to the values of subsequent round propensities. In order to increase the accuracy of the multiplier further, the multiplicand should be disaggregated into its component parts and the appropriate first round propensity applied to each component. Where feasible, specific estimations for second round propensities should also be utilised.

[3] In order to simplify calculations, the multiplier is often conceptualised as a process with several distinct stages or rounds. Broadly speaking, these stages will represent the initial injection; the backward and forward linkage effects of this initial stage on other industries; and increases in capacity (that is, induced investment) which result from the previous stages of the process.

The greatest criticism of the Keynesian multiplier arises from the fact that it is only able to provide an aggregate estimate of the effects of an expenditure change. In its simplest form, the Keynesian model provides a single value for the regional multiplier which is assumed to be equal to the individual multipliers for each regional industry. Various modifications to the form of the Keynesian regional multiplier have been suggested in an attempt to develop a more accurate and useful model, and to show how variables other than employment and income may change in response to expenditure changes. One such method is to make use of econometric modelling techniques to provide a detailed disaggregation of the effects of expenditure changes. The success of such models is constrained by the availability and cost of the necessary data, and the increasing complexity of more accurate (that is, more disaggregated) models.

## 2.4 Input output Analysis

Most recently, the application of computer modelling, based on an input-output approach, has helped to overcome a number of practical problems associated with the modelling of more complex situations. The technique of input-output analysis, as developed by Leontief, concentrates on the linkages between economic activities in a region. Where the simple multiplier provides only an estimation, in terms of income or employment, of the end result of a change in expenditure, the input-output model is able to predict the effect of a given change in one part of a regional economic system on any other part of that system. The main advantage of the regional input-output multiplier model is its ability to bring out the interdependencies which exist among all sectors of an economy (Weiss and Gooding, 1968).

The basis of the conventional input-output model is production: firms purchase inputs in order to produce outputs. The transactions table shows exactly from where the inputs of an industry come, and where the output of an industry goes. This is achieved by dividing the economy into $i = j$ sectors and following the stages of production as a good or service moves towards its final sale.

The equations used to construct the transactions table (from a purchasing viewpoint) are as follows:

(2.16) $Y_j = x_{1j} + x_{2j} + .....x_{ij} + F_j + M_j$

where $Y_j$ is the gross money value of inputs of purchasing-industry j; $x_{ij}$ is the money value of intermediate sales from selling-industry i to purchasing-industry j; $F_j$ is the final payments of purchasing sector j (that is, wages and gross operating surplus); and $M_j$ is purchases from the rest of the world.

This equation represents a purchasing point of view. The same model from a sales point of view can be represented as follows:

(2.17) $Y_i = x_{i1} + x_{i2} + .....+ x_{ij} + D_i$

where $Y_i$ is the gross money value of outputs of selling-industry i; $x_{ij}$ is defined as before; and $D_i$ represents sales of selling-industry i to its final uses (consumption, government, investment and export spending).

Lichty and Steinnes (1982) point out that the transactions table is descriptive rather than analytical - it quantifies the interdependencies prevailing in the economic system, but serves no purpose as a forecasting device. In order to investigate the industry production flows that form the essence of input-output analysis, it is necessary to construct a technical coefficients matrix. This is done by expressing the inputs required by each purchasing industry in the form of intermediate outputs from the selling industries, as a percentage of the gross output of the purchasing industry:

(2.18) $a_{ij} = \frac{x_{ij}}{Y_j}$

where $a_{ij}$ is the technical coefficient relating $x_{ij}$ to $Y_j$.

Following from this, it is possible to say that:

(2.19) $Y_i = a_{ij} Y_j + D_i$

A technical coefficients matrix is thus constructed using the information in the transactions table. From the technical coefficients matrix it can be observed that the required change in inputs could be obtained by multiplying the change in final demand by the relevant technical coefficient. This, however, provides only the direct effect of a given change in final demand - the industry supplying the extra input may itself require extra inputs in order to increase its own output. The inter-industry links within the system will thus cause a chain reaction of indirect effects which must be accounted for. This is achieved by expressing the entire model in matrix form. From the resulting matrix, industrial demand multipliers (or sectoral output multipliers) can be calculated. These multipliers show the total increase in output that would arise from a unitary increase (in money value) in the output of each industry.

While the input-output model is generally regarded as providing the most comprehensive measure of indirect and induced effects of the multiplier process, the time and cost constraints of obtaining the large volume of information required to develop the transactions table from which the model is derived are often prohibitive. A further problem is the need to assume stability of the relationships embodied in the table (and therefore in the derived technical coefficients ($a_{ij}$) table), in order to maintain internal consistency in the model. For example, changes in production techniques over time will change input-output linkages, leading to considerable errors in predicting the impact of a change in final demand on the output level of each industry. As Kuehn et al (1985) note, input-output models are unable to deal with the dynamics of structural change, such as the entry of new industries or the obsolescence of old ones, and effectively provide only a snapshot of a local economy at a point in time, given some historic economic structure.

## 2.5 The Dynamic Nature of the Regional Multiplier

As observed by Armstrong and Taylor (1978), the multiplier is essentially a dynamic concept. The time path of income resulting from a given injection into an economy will vary over time depending on the type of injection and the characteristics of the region. For example, a once-off investment in a special event may result in little further expansion over time, while an investment in the construction of a sports stadium over a period of years can lead to long term expansion. The degree of excess capacity, the various lags involved in consumers' expenditure and suppliers' reaction, and the size and industrial composition of the region in question will also affect the extent to which induced investment impacts on the multiplier process. Brownrigg (1971) notes that induced investment is likely to occur in response to permanent changes in income only, that is, as a result of new wages paid to *permanent* workers employed on the project that is giving rise to the initial injection. He suggests that induced investment will fall away as a component of the multiplier once there are no longer any sustained initial increases in income. The multiplier will thus be most useful if it can be estimated through time, in this way reflecting changing propensities and changing situational characteristics.

In examining the dynamic properties of the multiplier, Hartman and Seckler (1970) developed a general difference equation of regional income, which they used to estimate the extent to which a region could reach a level of self-sustaining endogenous growth. The authors emphasise that structural change is an important variable to be included in any model of regional growth. The reasoning behind this is that growth will contain components of both autonomous and induced investment. While the former element may have no permanent (long term) effect on the economy, the latter may result in real expansion, and a change in the import-export (and thus industrial) structure of the economy.

## 2.6 Rounds and Time Periods - Classifying Multiplier Effects

Policy makers are as concerned with intermediate, or short term effects, as with the final outcome of a given change in an economic system. In order to simplify calculations, the multiplier effect is often conceptualised as a process with several distinct stages. Tomlinson (1983) defines Miernyk's three stages of the multiplier, as follows:
(1) the *direct stage*, which reflects the effect of the initial autonomous change and/or changes in output in the industries which initiate the process;
(2) the *indirect stage*, which reflects "intermediate interindustry transactions", or the backward and forward linkage effects of the direct stage on other industries; and
(3) the *induced stage*, during which the direct and indirect stages of the multiplier effect work together, incorporating consumption linkages, to create extra income and demand in the economy. This final stage could also include induced investment leading to the expansion of capacity.

Sinclair and Sutcliffe (1989:1621) emphasise the relevance of estimating the timing of income changes, and the importance of being able to measure the change in income arising from an incomplete multiplier process (i.e. short run, or truncated multiplier estimates). They distinguish between rounds and time periods of the multiplier process, on the basis that "it is unlikely that the value of the truncated multiplier for $n$ rounds is equal to the truncated multiplier value for $n$ time periods".

The authors define the first round of the multiplier as beginning with the initial injection, and ending when this injection is fully converted into a change in the defined form of income. Further rounds of the multiplier process then begin when a proportion of this change is spent and end when the total subsequent change in the defined form of income has occurred. As a result of time lags in the process, one round of the multiplier process is likely to begin before the previous round is completed. Thus it is apparent that rounds of the multiplier do not necessarily occur in chronological order, and that the multiplier value after a given number of rounds is unlikely to be the same as the multiplier estimate after the same number of time periods.

Other authors have sought less complex definitions for the components of the multiplier

effect. McNicoll (1981) conceptualises the multiplier process not on the basis of time periods or stages, but in terms of different *types* of effects on income. He proposes the multiplier effect to be made up of *direct income effects*, which are generated within a particular industry, and *secondary income effects*, which are those generated in other parts of the economy through interindustry interaction. He further divides secondary income creation into *indirect effects*, which occur when income is created in the local economy by the operational purchases of the industry in question from other local sectors; and *induced effects*, which result from income generated locally through the consumption expenditures made by the direct income recipients.

## 2.7 Conclusion

The ability of a regional multiplier model to measure secondary and intermediate effects is, to a large extent, a measure of its usefulness and applicability. Some trade off usually occurs, however, in the form of the amount and cost of the data required and the accuracy and complexity of each model. McNicoll (1981) points out that, while the economic base approach, Keynesian multiplier and input-output model are unlikely to provide the same multiplier estimates, the loss in relative accuracy of the former two models is often more than offset by their cost-saving advantages.

The simplicity of the economic base theory makes it an attractive and popular choice for studies of small local economies, in which the shortcomings of the model are minimised. As Frey (1989) suggests, the focus of the economic base model on exports should represent no significant problem in application of the theory, since a fully elaborated model will be able to generate multipliers for any source of autonomous demand contained in the model.

In what follows, the differential economic base multiplier model developed by Weiss and Gooding (1968) is used as a conceptual basis for the development of a more complex differentiated multiplier model. Progressively more complex scenarios are modelled. Initially, the effects of two different investment projects on a homogeneous economy are examined. This is followed by an investigation of the differential effects of a single project within different sectors of the economy, using as a practical example a proposed zinc refinery and phosphoric acid plant project in the Eastern Cape province of South Africa. An

attempt is also made to model a limited number of relevant economic linkages.

# 3. A CONCEPTUAL MODEL OF THE DIFFERENTIAL MULTIPLIER

## 3.1 Introduction

This chapter makes use of the differential multiplier model developed by Weiss and Gooding (1968) to demonstrate the manner in which the differential effects of other sources of autonomous impacts, such as different investment projects, can be modelled to show their impact on the service or local sector of the economy. This acts as a conceptual basis for the development of a more complex differential multiplier model in the following chapter.

## 3.2 The Differential Multiplier Model of Weiss and Gooding

The differential multiplier model proposed by Weiss and Gooding (1968) generates differential multiplier estimates for different sectors of export activity, and considers the effects of changes in these sectors on total employment. Weiss and Gooding hypothesise that the separate export sectors have differential effects on total service jobs. These differential effects could be a result of differing degrees of local inter-industry linkages or from differences in the consumption behaviour of workers in the separate export sectors.

The authors suggest further that subsequent changes within the service sector itself will be the same regardless of which component of the export sector initially changed and stimulated a direct response in the service sector. In other words, the marginal ratio of induced to direct changes in service employment is the same for all service industries. The model thus assumes that workers in the separate export industries have different propensities to consume local and imported goods, while no such difference exists within the service sector; and all local workers divide their local spending between service activities in the same way.

The two assumptions on which the model is based deserve some discussion. The first assumption is that negligible inter-industry linkages should exist among the export industries. Independence among these industries is necessary if changes in each export

sector are to be considered exogenous. A further assumption requires the service industries to be homogeneous in industrial composition, so that firms and workers in the export sectors have similar patterns of local expenditure among the service activities.

The likelihood of these assumptions holding completely seems remote. However, Weiss and Gooding emphasise that the limitations of the economic-base type multiplier are minimised when dealing with small regions because of the inverse relationship that generally exists between the size of a region, and its dependence on exports. Nevertheless, they caution that disaggregation to more than about three export sectors is unlikely to be justifiable within the framework of their model, since the assumptions of the model require certain input-output relations to be uncomplicated.

## 3.3 The Weiss and Gooding Model Applied to Different Investment Projects

It is a relatively uncomplicated procedure to apply the Weiss and Gooding model to other sectors of economic activity. One example of such an application is the derivation of differential multiplier estimates for different investment projects. At a general level it is possible to distinguish between two types of investment projects: one which has a high capital and import content and uses mostly sophisticated technology with a relatively high proportion of skilled or imported labour; and one which has a low capital and import content, uses mostly unskilled workers, and makes extensive use of sub-contracting within the local economy. These projects are likely to differ in terms of their propensities to import capital goods (which will affect their linkages with local industries) and in the consumption behaviour of their workers.

With reference to the discussion on the multiplier process presented above, the standard formulation of the multiplier suggests that the direct and indirect stages of the multiplier usually occur during the first round of the multiplier process. The third, or induced, stage is then spread over the remaining multiplier rounds. In the case of a particular investment project, i, it is possible to define the first round as follows:

$$(3.1) \quad Y_i = I_i\{p_i(1-m_i^*)+(1-p_i)\}$$

where $Y_1$ is the change in regional income during the first round of the multiplier process; $I_i$ is the value of the initial investment; $p_i$ is the proportion of the initial investment spent on construction and other activities not repeated in the in subsequent periods (i.e. "once off activities"); $m_i^*$ is the initial injection leakage[1], or the proportion spent on imported capital and intermediate goods during the construction phase; and $(1 - p_i)$ represents the permanent or on-going component, which is made up largely of the wages of new workers.

During the second round of the multiplier process, workers employed on project i spend part of the initial increase in their income on the consumption of local and imported goods and services, while saving the remainder. This second round is represented as follows:

$$(3.2) \quad Y_2 = c_i(1-m_i)I_i\{p_i(1-m_i^*)+(1-p_i)\}$$

where $c_i$ represents the propensity to consume and $m_i$ the propensity to import consumer goods and services on the part of workers on project i.

In the same way, during the third and subsequent rounds, workers in the rest of the economy (that is, workers in the service sector) spend some proportion of the increase in their incomes (the value added) in previous rounds on consuming local and imported goods and services, and save the remainder. Following the argument of Weiss and Gooding the relevant propensities of these workers are assumed to be the same. The third and fourth rounds of the multiplier can thus be represented by:

$$(3.3) \quad Y_3 = c_r(1-m_r)Y_2$$

$$(3.4) \quad Y_4 = c_r(1-m_r)Y_3$$

where $c_r$ and $m_r$ are the propensities of workers in the service sector to consume and import consumer goods and services.

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[1] Following Brownrigg (1971) an injection leakage is applied only to the temporary or construction component of the initial injection

Given q rounds of the multiplier process, and rearranging terms:

$$(3.5)\quad Y_i = Y_1 + Y_2 + Y_3 + \ldots\ldots + Y_q$$

$$= Y_1 + Y_2[1 + c_r(1-m_r) + \{c_r(1-m_r)\}^2 + \ldots\ldots]$$

$$= [1 + \frac{c_i(1-m_i)}{1-c_r(1-m_r)}]I_i\{p_i(1-m_i^*) + (1-p_i)\}$$

$$= k_i I_i\{p_i(1-m_i^*) + (1-p_i)\}$$

where $Y_i$ is the increase in income made possible through investment project i, and $k_i$ is the corresponding investment multiplier. For two or more investment projects

$$(3.6)\quad \sum Y_i = \sum k_i I_i\{p_i(1-m_i^*) + (1-p_i)\}$$

The change in regional income will clearly depend on the relative magnitudes of the investment multipliers, and thus on $c_i$ and $m_i$. The values of $p_i$ and $m_i^*$ will also affect the change in income. A skill-intensive project with a higher capital:labour ratio is likely to have a higher $p_i$ and a higher $m_i^*$, since a greater proportion of the initial injection is likely to be spent on equipment, relatively more of which will be specialised imported goods. The $k_i$ value for such a project is, however, likely to be lower than its labour-intensive counterpart. If the value of the initial investment under the two projects is the same, it follows that the more labour-intensive project will boost regional income by a greater margin.

## 3.4 Induced Investment

While each of the initial investments will trigger a multiplier-induced increases in income, each of these latter increases may, in turn, induce further investments. It can be reasonably assumed that local enterprises will base their investment decisions on the what they perceive as permanent rather than temporary changes in expenditure and income. Induced investment will thus depend on the permanent change in regional income during the previous period (Black, 1996). The permanent change in income is simply the total change, $\sum Y_i$, net of its "once-off" or construction component. That is

$$(3.7) \quad Y_t^P = \sum Y_{i,t}^P = \sum k_i I_{i,t}(1 - p_i)$$

where $Y_t^P$ is the permanent change in regional income in period t.

Induced investment may itself also consist of the kinds of projects mentioned above (e.g. i = 1,2), and in each case this is likely to be made up of a construction component and an ongoing wages component. Given the convergent nature of changes in regional income over time (Black 1996), it is necessary to focus only on the permanent component of induced investment. Permanently induced investment in period t+1 can be represented by:

$$(3.8) \quad N_{t+1} = \sum n_i Y_t^P(1 - p_i)$$

where $n_i$ is the investment coefficient applicable to the relevant project.

The permanent change in income in period t+1 is given by:

$$(3.9) \quad Y_{t+1}^P = \sum k_i n_i Y_t^P(1 - p_i)$$

and in period t+2 by:

$$(3.10)\quad Y^{p}_{t+2} = \sum k_i n_i Y^{p}_{t+1}(1-p) Y^{p}_{t+2}$$
$$= \{\sum k_i n_i (1-p_i)\}^2 Y^{p}_{t}$$

From this the sum of permanent changes in regional income can be obtained as follows:

$$(3.11)\quad Y^{p} = Y^{p}_{t}[1 + k_i n_i (1-p_i) + \{k_i n_i (1-p_i)\}^2 + .....$$

Given fairly realistic values for the coefficients embodied in the above equation, the geometric series can be assumed to be convergent (Black, 1996). Thus;

$$(3.12)\quad Y^{p} = \frac{Y^{p}_{t}}{1 - \sum k_i n_i (1-p_i)}$$

and substituting

$$(3.13)\quad Y^{p} = \frac{\sum k_i I_{i,t} (1-p_i)}{1 - \sum k_i n_i (1-p_i)}$$

A given investment can thus be seen to have two effects on the local economy: firstly, a multiplier effect in terms of which the level of local income increases by some multiple of the initial investment; and secondly, an induced investment effect according to which local enterprise may invest in projects of different kinds (e.g. $N_{1,t+1}$ and $N_{2,t+1}$).

While the multiplier effect of a given initial investment will depend on whether the project is predominantly capital (and skill) intensive or labour intensive, either project may induce further investments of both a capital intensive and a labour intensive nature. The induced investment effect will, however, also depend on the degree of capacity utilisation within the local economy, as well as on the type of investment project required to expand capacity in those sectors operating at full capacity (Black and Saxby, 1996).

# 4. DEVELOPMENT OF A GENERAL DIFFERENTIAL MULTIPLIER MODEL

## 4.1 Introduction to the General Model

The generic version of the following proposed model makes allowance for inter-industry linkages within the region, as well as specifying the initial import leakages which occur at each link in the production chain. These leakages refer to imported capital and intermediate goods and services (hereafter referred to as "materials"), and are distinct from those included in the multiplier itself, which also include imported consumer goods. The former leakages occur during the investment stage and at the beginning of the production cycle, that is, before the multiplier process is set in motion.

Following Brownrigg's argument a distinction was made between the construction (or "once-off") and the production (or permanent) phases of the project. Apart from the fact that the construction phase is of a temporary nature only while the production phase is more permanent and gives rise to a sustained change in regional income through the multiplier process, these phases are likely to differ in respect of their propensities to import capital and intermediate goods, their consequent linkages with the local economy, and also in terms of their use of skilled relative to unskilled labour. It is also clear that these phases of the project are likely to occur during different time periods, with the construction phase normally being completed before, or shortly after, the plant becomes operational.

During the construction phase of a particular investment project, P, all activities are assumed to be subcontracted to construction and related industries within the region (given by j = 1,2,....n in the model below). Each of these industries divides its total spending between paying its own workforce, acquiring materials from outside the region ($m_{rj}$) and acquiring materials from industries within the region ($m_{vj}$ where v = 1, 2, ...n, n+1, ...n+q)[1]. All further backward leakages are accounted for in a similar manner. The (annual) amount spent on the operational (production) phase of project P will likewise be divided between acquiring materials from outside the region ($m_{rp}$) and from other industries within the region ($m_{vp}$), and paying permanent employees working on the project.

## 4.2 First Round of the Multiplier Process

It is useful to view the operation of the multiplier in terms of value added during several rounds of the multiplier process. For any particular investment project (P), the initial value added can be given by $Q_p$, of which some portion, $\alpha$, represents once-off spending on construction (assumed to fall away after a period of one to two years); and the remaining portion, (1-$\alpha$), represents recurrent spending on the annual operation of the project. During the construction phase of the project, all activities are assumed to be sub-contracted to industries within the region, so that $\alpha Q_p = \sum_{j=1}^{n} Q_j$.

The change in regional income during the **first round** of the multiplier process can thus be represented as follows:

(4.1)....

$$Y_1 = \sum_{j=1}^{n} Q_j\{1 - m_{rj} - \sum_{v=1}^{n+q}\sum_{w=1}^{n+q}(m_{vj}m_{rv} + m_{vj}m_{wv}m_{rw})\} + (1-\alpha)Q_p\{1 - m_{rp} - \sum_{v=1}^{n+q}\sum_{w=1}^{n+q}(m_{vp}m_{rv} + m_{vp}m_{wv}m_{rw})$$

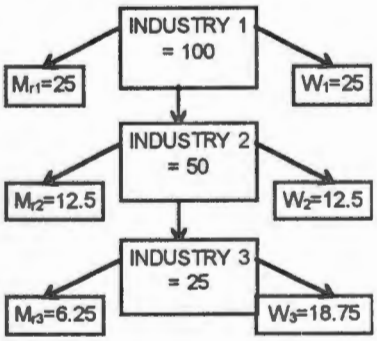
where $(1-\alpha)Q_p$ is the (annual) amount spent on the operational (or production) phase of project P; $m_{rj}$, $m_{rp}$, $m_{rv}$, and $m_{rw}$ are the propensities to import materials from the rest of the world (that is, other regions and countries); and $m_{vj}$, $m_{vp}$, and $m_{wv}$ are the inter-industry

[1] As Brownrigg (1971) notes, the problem of undistributed profits is conventionally ignored in the multiplier

coefficients.

The above model can be depicted by means of a simple schematic illustration. In the following example, the first round multiplier effects arising from an autonomous injection of R100 into the construction phase of project P are modelled using the simplest case scenario, where industry 1 (j = 1) buys materials from industry 2, industry 2 from industry 3, and so on.

**Diagram 1. Schematic Illustration of the First Round Multiplier Effects Arising from the Construction Component of Project P**




Each industry thus directs 25% of its total spending to materials acquired from outside the region ($M_{ri}$); 50% to materials acquired from another industry in the region; and the remainder to wages. Applying the above equation, we have a first round increase in regional income amounting to:

$$Y_1 = 100\{1 - 0.25 - 0.5(0.25) - 0.5(0.5)(0.25)\} = 56.25$$

As explained above, the model effectively captures and "removes" all import leakages at all linkages in the production chain occurring during the first round of the multiplier process (that is, before the multiplier itself comes into play). The value added (represented by the increase in regional income) at the end of the first round of the multiplier process thus represents the proportion of the initial investment which is ultimately spent on wages in the region. Returning to our numerical example, we would therefore expect the difference between the initial injection (R100) and the sum of the $M_{ri}$ (that is, the total imports) and to be equal to the first round increase in income (R56.25).

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model. For our purposes, profits are treated similarly to wages.

Calculating total imports, we have:

$$25+12.5+6.25=43.74$$

Subtracting imports from the initial investment gives us:

$$100-43.75=56.25$$

which amount is equal to the value added (or expenditure on wages) resulting from the first round of the multiplier process.

Returning to our generic model, we can simplify as follows:

Letting

$$(4.2)\quad \alpha Q_p = \sum_{j=1}^{n} Q_j$$

$$(4.3)\quad m_j^* = \sum_{j=1}^{n} m_{rj} + \sum_{v=1}^{n+q}\sum_{w=1}^{n+q} (m_{vj}m_{rv} + m_{vj}m_{wv}m_{rw})$$

$$(4.4)\quad m_p^* = m_{rp} + \sum_{v=1}^{n+q}\sum_{w=1}^{n+q} (m_{vp}m_{rv} + m_{vp}m_{wv}m_{rw})$$

then:

$$(4.5)\quad Y_1 = \alpha Q_p(1-m_j^*)+(1-\alpha)Q_p(1-m_p^*)$$
$$= Q_p\{\alpha(1-m_j^*)+(1-\alpha)(1-m_p^*)\}$$

## 4.3 Second and Subsequent Rounds of the Multiplier Process

The multiplier process itself can be viewed in terms of value added during three broadly defined stages (e.g. Miernyk, 1968; Thompson, 1983). During the *direct* stage, the income of the region increases by the value of the initial injection (less initial import leakages), or by the increased output of the industries which initiate the process. The *indirect* stage reflects the increased demand for capital and intermediate inputs from other industries (that is, the relevant forward and backward linkages). According to the standard formulation of the multiplier, these two stages are included in the **first round** of the multiplier process, while the *third* or *induced* stage, which incorporates the various consumption linkages between and amongst the latter industries and the rest of the local economies, is spread over all the **remaining rounds**.

During the **second round** of the multiplier process, workers employed on either phase of project P spend part of the initial increase in income on consuming local and imported goods and services, and save the remaining part. The second round of the multiplier is represented by:

$$(4.6)\quad Y_2 = c'_j Q_p \alpha(1-m^*_j)+c'_p Q_p(1-\alpha)(1-m^*_p)$$
$$= Q_p\{c'_j\alpha(1-m^*_j)+c'_p(1-\alpha)(1-m^*_p)\}$$

where $c'_j$ is the propensity to consume of workers in the construction and related industries, net of all imports and taxes and weighted in terms of the corresponding ratio of skilled to unskilled workers; and $c'_p$ is the propensity to consume of permanent workers employed on the production stage of the project, similarly defined. Thus:

$$(4.7)\quad c'_j = c'_s(S_j/T_j)+c'_u(U_j/T_j)$$

$$(4.8)\quad T_j = S_j + U_j$$

$$(4.9)\quad c'_p = c'_s(S_p/T_p)+c'_u(U_p/T_p)$$

(4.10) $T_p = S_p + U_p$

(4.11) $c'_s = c_s(1-t_s)(1-m_s-t_i)$

(4.12) $c'_u = c_u(1-t_u)(1-m_u-t_i)$

where $T_j$ is the total number of workers employed in the construction sector; $S_j$ and $U_j$ are the corresponding number of skilled and unskilled workers, respectively; $T_p$ is the total number of workers employed on the production phase of the project, divided into skilled and unskilled workers ($S_p$ and $U_p$, respectively); $c_s$ ($c_u$) is the consumption propensity of skilled (unskilled) workers; $t_s$ ($t_u$) is the direct tax propensity of skilled (unskilled) workers; $m_s$ ($m_u$) is the propensity to import on the part of skilled (unskilled) workers[2]; and $t_i$ represents the indirect tax leakage.

During the **third** and **subsequent rounds** of the multiplier process workers in the rest of the economy, or the "service sector", spend part of the value added in previous rounds on consuming local and imported goods and services, and save the rest. These proportions are again assumed to vary in accordance with the level of skills of the workers. Thus the third and fourth rounds of the multiplier process are given by :

(4.13) $Y_3 = c'_d(Y_2)$

(4.14) $Y_4 = c'_d(Y_3)$

where $c'_d$ is the propensity to consume on the part of workers in the rest of the local economy, net of taxes and imports and suitably weighted in terms of the ratio of skilled to unskilled workers in the local economy; that is:

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[2] $m_u$ and $m_s$ are defined similarly to $m^*_p$ and $m^*_j$, in that they incorporate import leakages at all links in the production chain.

(4.15) $c'_d = c'_s(S_d/T_d)+c'_u(U_d/T_d)$

(4.16) $T_d = S_d + U_d$

where the symbols now refer to workers in the rest of the local economy.

Given z rounds of the multiplier process, and rearranging terms, we have :

(4.17) $Y_P = Y_\alpha + Y_{(1-\alpha)}$

$$= Y_{\alpha_1} + Y_{\alpha_2} + \ldots + Y_{\alpha_z} + Y_{(1-\alpha)_1} + Y_{(1-\alpha)_2} + \ldots + Y_{(1-\alpha)_z}$$

$$= (Y_{\alpha_1} + Y_{(1-\alpha)_1}) + (Y_{\alpha_2} + Y_{(1-\alpha)_2}) + \ldots + (Y_{\alpha_z} + Y_{(1-\alpha)_z})$$

$$= Y_{\alpha_1}[1 + c'_j\{1 + c'_d + (c'_d)^2 + \ldots\}] + Y_{(1-\alpha)_1}[1 + c'_p\{1 + c'_d + (c'_d)^2 + \ldots\}]$$

$$= \{1 + \frac{c'_j}{(1-c'_d)}\}\alpha Q_p(1-m^*_j) + \{1 + \frac{c'_p}{(1-c'_d)}\}(1-\alpha)Q_p(1-m^*_p)$$

$$= k_j Q_p \alpha(1-m^*_j) + k_p Q_p(1-\alpha)(1-m^*_p)$$

$$= Q_p\{k_j\alpha(1-m^*_j) + k_p(1-\alpha)(1-m^*_p)\}$$

where $Y_p$ is the total (temporary and permanent) increase in income made possible by project P as a whole and is equal to the final increase in income resulting from the construction phase of the project ($Y_\alpha$)and from the production phase of the project; ($Y_{(1-\alpha)}$); $Y_{\alpha_1}$ and $Y_{(1-\alpha)_1}$ ($Y_{\alpha_2}$ and $Y_{(1-\alpha)_2}$, etc.) represent the changes in regional income resulting from the first (second, etc.) round of the multiplier process arising from the construction and production components of project P, respectively; and $k_j$ and $k_p$ are the corresponding regional multipliers for the construction and production phases of the project.

It is clear that the change in regional income will depend on the values of $Q_p$, $\alpha$, $m_j^*$ and $m_p^*$; the size of the multipliers, $k_j$ and $k_p$ applicable to the production and construction phases, respectively; and on the values of all the coefficients embodied in the multipliers, themselves.

Similarly, the **permanent** increase in income arising from project P will be given by:

$$(4.18)\quad Y_{(1-\alpha)} = k_p Q_p (1-\alpha)(1-m_p^*)$$

## 4.4 Induced Investment

It is as well to emphasise that it is only the production phase that will have a potentially permanent impact on the local economy; the effects of construction fall away after a period of time. It also seems reasonable to assume that local enterprises will base their investment decisions on what they believe to be a permanent, rather than a temporary, change in expenditure and income. Induced investment will thus depend on the permanent change in regional income during the same (or previous) period, and also on the degree of capacity utilisation among local industries (Black, 1996). This implies that it is only the production phase, rather than the temporary construction phase, that can be expected to induce further investment within the local economy.

Induced investment may itself consist of construction and production phases. Given the convergent nature of changes in regional income over time (Black, 1996), it is only the latter type of investment that will have a lasting effect on the local economy. In either case, however, we may define an induced investment function in respect of some local project, N, in terms of the above model, as follows:

$$(4.19)\quad N = nY_{(1-\alpha)}\{\beta(1-m_j^*)+(1-\beta)(1-m_n^*)\}$$

$$= n\{k_p Q_p (1-\alpha)(1-m_p^*)\}\{\beta(1-m_j^*)+(1-\beta)(1-m_n^*)\}$$

where $Y_{(1-\alpha)}$ is the (multiplier-induced) increase in income brought about by the (permanent) production phase of project, P; n is the investment coefficient applicable to the latter increase

in income; and β, (1-β) and $m_n^*$ now refer to the induced project, N.

As before,

(4.20) $Y_n = \{nk_pQ_p(1-\alpha)(1-m_p^*)\}\{k_j\beta(1-m_j^*)+k_n\beta(1-m_n^*)\}$

where $Y_n$ is the total change in income generated by induced investment project N. It is important to note that $Y_n$ represents both temporary and permanent (induced) increases in income. Over time, the temporary component of induced investment is likely to fall away, so that the permanent increase in income resulting from induced investment will be:

(4.21) $Y_{(1-\beta)} = \{nk_pQ_p(1-\alpha)(1-m_p^*)\}\{k_n(1-\beta)(1-m_n^*)\}$

Thus, a new investment, such as project P, essentially has two effects on the local economy:
(i) a multiplier effect in terms of which the level of regional income increases by a particular multiple of the original investment (that is, $Y_p$) ; and
(ii) an induced investment effect according to which local enterprises may invest in projects of a different kind, thus triggering further increases in income (that is, $Y_n$).

While the latter effect arises only from the permanent increase in income resulting from the initial multiplier outcome, each of these effects will consist of a temporary (or construction) and a permanent (or production) component. The temporary component falls away after a time, so that the permanent sustained increase in income in the region is the sum of the permanent portions of these two effects.

# 5. APPLICATION OF THE DIFFERENTIAL MULTIPLIER MODEL

## 5.1 Introduction

The second chapter of this paper showed how, using the basic theory of the differential multiplier model developed by Weiss and Gooding (1968), a conceptual model could be developed to estimate the differing effects of distinct investment projects on the local sector. Working from this conceptual basis, a more complex differential multiplier model was developed in the previous section. This model divided an initial investment project into temporary and permanent components, each of which was treated separately (though similarly). The model also allowed for backward leakages occurring during all rounds of the multiplier process, before the multiplier itself comes into action. In this section we take the process one step further, and apply the generic model to a specific case study, to determine the type and extent of the economic impacts of a proposed zinc refinery and phosphoric acid plant development in the Eastern Cape Province of South Africa on the local and national economies.

The project proposes the construction of a new 220 000 tpa (tonnes per annum) zinc refinery, adjacent to which is being considered the erection of a 250 000 tpa phosphoric acid plant which will utilise the sulphuric acid produced as a co-product of the zinc refining process. Potential locations for the project have been identified in the coastal cities of Port Elizabeth and East London, in the Eastern Cape Province. The effects of the project on a local, regional and national level can be expected to vary in accordance with differences in local input requirements and in the propensities to consume local goods and services; and to the extent that they do, may ultimately give rise to different levels of induced investment. In what follows, the generic model of the differential multiplier will be applied to the local (sub-regional) economies of Port Elizabeth and East London, as well as to the economy of South Africa as a whole. Within each region, estimates were calculated for the project as a whole (the zinc refinery and the phosphoric acid plant combined), as well as for each plant individually.

Further details on the specifications of the projects are set out in Appendix 1, while Appendix 2 provides a brief outline of the economies of the two sub-regions of Port

Elizabeth and East London, as well as of the Eastern Cape Province.

## 5.2 Practical Application of the Model

The general model detailed in the previous chapter was used to simulate the economic impact of the proposed zinc refinery and phosphoric acid plant. For ease of calculation, the production and construction phases of the project were dealt with separately. In addition, separate estimates were calculated for each of the Port Elizabeth and East London sub-regions. A total of eight equations - and eight differential multipliers - were thus generated, depicting the differential effects of the construction and production phase of each plant in each of the two proposed sub-regions.

The equations used to calculate the multiplier effects of the project within the Port Elizabeth and East London sub-regions are detailed below. Superscripts PE and EL refer to the Port Elizabeth and East London sub-regions, respectively, while subscripts Z and Ph refer variously to the zinc refinery and the phosphoric acid plant. Other symbols are as previously defined, with the initial investment in the construction phase of each plant given by $\alpha Q$, while the annual investment in the production phase of each plant is given by $Q(1-\alpha)$. Thus equation (5.1) represents the (temporary) increase in income in Port Elizabeth resulting from the construction phase of the zinc refinery, while equation (5.8) represents the permanent (sustained) increase in East London's income resulting from the operation of the phosphoric acid plant.

(5.1) $$Y_{\alpha,Z}^{PE} = k_{j,Z}^{PE} \alpha_Z Q_Z (1 - m_{j,Z}^*)$$

(5.2) $$Y_{\alpha,Ph}^{PE} = k_{j,Ph}^{PE} \alpha_{Ph} Q_{Ph} (1 - m_{j,Ph}^*)$$

(5.3) $$Y_{(1-\alpha),Z}^{PE} = k_{p,Z}^{PE} Q_Z (1 - \alpha_Z)(1 - m_{p,Z}^*)$$

(5.4) $$Y_{(1-\alpha),Ph}^{PE} = k_{p,Ph}^{PE} Q_{Ph} (1 - \alpha_{Ph})(1 - m_{p,Ph}^*)$$

(5.5) $$Y_{\alpha,Z}^{EL} = k_{j,Z}^{EL} \alpha_Z Q_Z (1 - m_{j,Z}^*)$$

(5.6) $Y^{EL}_{\alpha,Ph} = k^{EL}_{j,Ph}\alpha_{Ph}Q_{PH}(1-m^{*}_{j,Ph})$

(5.7) $Y^{EL}_{(1-\alpha),Z} = k^{EL}_{p,Z}Q_{Z}(1-\alpha_{Z})(1-m^{*}_{p,Z})$

(5.8) $Y^{EL}_{(1-\alpha),Ph} = k^{EL}_{p,Ph}Q_{Ph}(1-\alpha_{Ph})(1-m^{*}_{p,Ph})$

A similar set of multiplier models was used to calculate the effects of the zinc refinery and the phosphoric acid plant on the economy of South Africa as a whole (represented by the superscript SA).

(5.9) $Y^{SA}_{\alpha,Z} = k^{SA}_{j,Z}\alpha_{Z}Q_{Z}(1-m^{*}_{j,Z})$

(5.10) $Y^{SA}_{\alpha,Ph} = k^{SA}_{j,Ph}\alpha_{Ph}Q_{Ph}(1-m^{*}_{j,Ph})$

(5.11) $Y^{SA}_{(1-\alpha),Z} = k^{SA}_{p,Z}Q_{Z}(1-\alpha_{Z})(1-m^{*}_{p,Z})$

(5.12) $Y^{SA}_{(1-\alpha),Ph} = k^{SA}_{p,Ph}Q_{Ph}(1-\alpha_{Ph})(1-m^{*}_{p,Ph})$

The induced stage of the multiplier process was based only on the permanent changes in income which arose from the annual (that is, continuous) impact of the production phase of the project. Thus, only four equations - two for each region - were generated in calculating the increase in income resulting from induced investment:

(5.13) $Y^{PE}_{n,Z} = nY^{PE}_{(1-\alpha),Z}\{k_{j}\beta(1-m^{*}_{j})+k_{n}(1-\beta)(1-m^{*}_{n})\}$

(5.14) $Y^{PE}_{n,Ph} = nY^{PE}_{(1-\alpha),Ph}\{k_{j}\beta(1-m^{*}_{j})+k_{n}(1-\beta)(1-m^{*}_{n})\}$

(5.15) $Y^{EL}_{n,Z} = nY^{EL}_{(1-\alpha),Z}\{k_{j}\beta(1-m^{*}_{j})+k_{n}(1-\beta)(1-m^{*}_{n})\}$

(5.16) $Y^{EL}_{n,Ph} = nY^{EL}_{(1-\alpha),Ph}\{k_j\beta(1-m^*_j)+k_n(1-\beta)(1-m^*_n)\}$

where the symbols refer to induced investment project N. As before, a similar set of equations was used to calculate the induced investment effect in the country as a whole:

(5.17) $Y^{SA}_{n,Z} = nY^{SA}_{(1-\alpha),Z}\{k_j\beta(1-m^*_j)+k_n(1-\beta)(1-m^*_n)\}$

(5.18) $Y^{SA}_{n,Ph} = nY^{SA}_{(1-\alpha),Ph}\{k_j\beta(1-m^*_j)+k_n(1-\beta)(1-m^*_n)\}$

## 5.3 Results of Model

Estimated values for the various coefficients used in the impact analysis are provided in Appendix 3. These have been derived from a number of different sources, including information supplied by the companies proposing the project, the Central Statistical Service's Survey of Household Expenditure (1990) and its October Household Survey for the Eastern Cape (1994), the Development Bank of Southern Africa, and several other sources indicated in the list of references. Table 1 below provides estimates of the differential multipliers and corresponding income changes generated by the zinc refinery and the phosphoric acid plant.

## Table 1. Estimated Values of Differential Multipliers and Corresponding Income Changes

| | | Initial Investment /Income[2] (R million) | Differential Multiplier[3] | Increase in Income (R million) | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | Multiplier Induced Increase | Induced Investment | | Further Permanent Increase[5] | Total Permanent Increase[6] |
| | | | | | Local[4] | Permanent | | |
| Port Elizabeth | Zinc: construction | 759.00 | 1.44 | 1091.56 | 0 | 0 | 0 | 0 |
| | Zinc: production[1] | 97.36 | 1.343 | 130.76 | 7.21 | 2.98 | 4.00 | 134.76 |
| | Phosphoric Acid: construction | 108.00 | 1.44 | 155.32 | 0 | 0 | 0 | 0 |
| | Phosphoric Acid: production | 17.37 | 1.343 | 23.33 | 1.28 | 0.42 | 0.57 | 23.90 |
| East London | Zinc: construction | 759.00 | 1.42 | 1 078.04 | 0 | 0 | 0 | 0 |
| | Zinc: production | 97.36 | 1.341 | 130.54 | 7.20 | 2.97 | 3.98 | 134.52 |
| | Phosphoric Acid: construction | 108.00 | 1.42 | 153.40 | 0 | 0 | 0 | 0 |
| | Phosphoric Acid: production | 17.37 | 1.341 | 23.29 | 1.28 | 0.42 | 0.57 | 23.86 |
| South Africa | Zinc: construction | 1 587.00 | 2.74 | 4 341.46 | 0 | 0 | 0 | 0 |
| | Zinc: production | 194.72 | 2.45 | 477.15 | 44.90 | 17.50 | 42.89 | 520.03 |
| | Phosphoric Acid: construction | 480.00 | 2.74 | 482.74 | 0 | 0 | 0 | 0 |
| | Phosphoric Acid: production | 23.16 | 2.45 | 56.75 | 5.36 | 1.67 | 4.08 | 60.83 |

Notes:

1. The operational (or production) phase of the project has an annual effect throughout the duration of the project
2. The initial investment/income represents the change in regional income arising from the first round of the multiplier process; that is before the multiplier itself comes into play. This figure thus represents the actual investment less the initial leakages at all stages of the production chain.
3. The value of the multiplier suggests that, for example, a R1 million injection into the economy in the form of the construction of the zinc refinery will lead to a temporary increase in the income of Port Elizabeth of R1.44 million
4. Local induced investment consists of both a once-off (construction) component and a permanent (ongoing) component.
5. Further permanent increases in income arise from the multiplied value of the permanent (ongoing) component of the induced investment project only.
6. The total permanent increase is thus the sum of the initial permanent increase and the permanent induced increase in income.
7. As a result of rounding, calculations using figures in this table may not produce exact results.

It can be seen from Table 1 that the value of the multiplier for the construction phase of each plant in one region is the same, but that it differs between regions, equalling 1.44 in Port Elizabeth, and 1.42 in East London. A similar scenario exists for the production phase of the project, with the multiplier being marginally higher in Port Elizabeth (1.343) compared to East London (1.341). These results arise primarily because the ratio of skilled to unskilled workers during the construction phase of the phosphoric acid plant and the zinc refinery is the same; while similarly, that for the production component of each plant is equal. In addition, the economic profiles of each region are relatively similar, giving very little variation in figures between the regions.

The estimated multipliers generate, in the case of Port Elizabeth, a temporary increase in income of R1091.56 million during the construction phase of the zinc refinery, and R155.32 million during the construction of the phosphoric acid plant. As the construction phase is considered temporary, permanent increases in income were calculated from the production phase of the project. The initial local increase in income of R97.36 million in the zinc refinery was estimated to lead to (multiplied) **annual** increases in income of R130.76 million during the operational life span of the refinery.

The impact on income in East London is in all cases slightly less than that in Port Elizabeth, as a result of the smaller multipliers obtained for the former region. Temporary increases of R1078.04 million and R155.40 million can be expected for the zinc refinery and phosphoric acid plant in East London, respectively, while the production phase of each plant is estimated to have an annual effect on income of R130.54 million (zinc refinery) and R23.29 million (phosphoric acid plant).

Local induced investment arising from the operational stages of the zinc refinery amounts to R7.21 million in Port Elizabeth and R7.20 million in East London. The induced investment generated by the phosphoric acid plant is considerably lower, amounting to R1.28 million in both Port Elizabeth and East London.

As induced investment can itself consist of a temporary (or construction) component, as well as a permanent component, further increases in income resulting from induced investment are expected to arise from the permanent component only. Thus induced investment has an

accelerator effect on the original multiplier process, as it is itself subject, at least in part, to its own multiplier process.

The additional (multiplied) increase in income arising from induced investment generated by the zinc refinery's operation amounts to R4 million in Port Elizabeth and R3.98 million in East London, while the phosphoric acid plant generates further increases in income of R0.57 million in both of the two sub-regions. The total permanent impact on each sub-region's income of the zinc refinery is thus R134.76 million (Port Elizabeth) and R134.52 million (East London). The phosphoric acid plant generates total permanent increases in income of R23.90 million in Port Elizabeth and R23.86 million in East London[1].

Since induced investment depends on sustained increases in income, the relatively small proportion of expenditure on wages, relative to that on material goods, in the production phase of the project, means that the permanent increases in income are not as high as they might otherwise have been. In addition, a relatively high proportion of goods and services imported from outside the region for use on the plants has the effect of dampening the final impact on income both through a reduction in the value of the initial investment (that is, the value of the actual investment less initial imports), and through a reduction of the multiplier values.

This latter point is illustrated by the considerably higher multiplier values obtained for South Africa as a whole, with a value of 2.74 for the construction phase of both plants, and a value of 2.45 for the production phase. These higher values are indicative of the relatively smaller proportion of goods which is imported from outside the country, compared to the proportion of goods imported from outside the Port Elizabeth and East London sub-regions. Similarly, the values of the initial investments are considerably higher for South Africa as a whole, leading to an overall greater potential impact on the country as a whole than on the two sub-

[1] Calculations of induced investment in this model should be considered as speculative, rather than exact. The difficulty of obtaining accurate data relevant to induced investment calculations has resulted in this aspect of the economic impact assessment being explicitly neglected in most studies. Armstrong (1993) discusses only the temporary construction activity likely to be induced through an increase in the number of students enrolled at Lancashire University, while Bleaney et al (1992, p.306-307) explicitly ignore induced investment in their calculations of the impact of Nottingham University on its local economy, on the grounds that any such estimates would be "extremely speculative". Brownrigg (1971) attempts to estimate the induced investment coefficient through a series of complex calculations relating capital requirements to immigrants' earnings, relating to a specific project. Inclusion of induced investment estimates in this model, therefore, serves the primary purpose of merely providing some idea of the manner in which induced investment can further impact

regions.

Because of the inter-relatedness of the phosphoric acid plant and the zinc refinery, results were also obtained for the impact of the two plants as a single combined project, as shown in Table 2 below.

**Table 2. Estimated Values of Differential Multipliers and Corresponding Changes in Income for the Combined Project**

| | | Initial Investment | Differential Multiplier | Increase in Income (R million) | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | Multiplier Induced Increase | Induced Investment | | Further Permanent Induced Increase | Total Permanent Increase |
| | | | | | Local | Permanent | | |
| Port Elizabeth | Construction Phase | 867.00 | 1.44 | 1246.88 | 0 | 0 | 0 | 0 |
| | Operational Phase | 114.73 | 1.343 | 154.09 | 8.49 | 3.33 | 4.47 | 158.57 |
| East London | Construction Phase | 867.00 | 1.42 | 1231.44 | 0 | 0 | 0 | 0 |
| | Operational Phase | 114.73 | 1.341 | 153.83 | 8.48 | 3.33 | 4.46 | 158.29 |
| South Africa | Construction Phase | 2065.00 | 2.74 | 5649.10 | 0 | 0 | 0 | 0 |
| | Operational Phase | 218.42 | 2.45 | 535.23 | 50.41 | 18.65 | 45.70 | 580.93 |

Despite the small differences in the estimated values between the regions, the figures nevertheless suggest that a greater absolute impact is likely in Port Elizabeth than in East London. This result is consistent with the assumption that East London, being the smaller sub-region, will experience a higher propensity for importing consumer goods, resulting in a correspondingly smaller impact remaining within the sub-region.

Table 3 below shows the results of the "combined project" as a percentage of the Gross Geographic Product of each sub-region (and of the Gross Domestic Product of South Africa). These figures indicate that the relative impact of the combined project will be greater in East London, which has the smaller economy and a correspondingly lower GGP. The more extensive economic linkages afforded by the greater size of the Port Elizabeth

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of the economy of a region. Appendix 3 details the manner in which induced investment was calculated

economy may, on the other hand, allow for impacts on the Port Elizabeth economy to have wider-reaching effects on surrounding areas.

**Table 3. Multiplied Increases in Income as a Percentage of GGP**

| | | Temporary increase in income (R million) | Total Permanent increase in Income (R million) | Percentage of GGP |
|---|---|---|---|---|
| Port Elizabeth[1] | Construction Phase | 1246.88 | | 13.1 |
| | Operational Phase | | 158.57 | 1.7 |
| East London[1] | Construction Phase | 1231.44 | | 24.2 |
| | Operational Phase | | 158.29 | 3.1 |
| South Africa[2] | Construction Phase | 5649.10 | | 1.2 |
| | Operational Phase | | 580.93 | 0.1 |

Notes:

1. GGP figures for Port Elizabeth and East London (1993 values expressed in 1996 prices) are R9 541.4 million and R5 080.9 million, respectively
2. The GDP figure South Africa for 1994 (expressed in 1996 prices) is R4 628 988.81 million.

The above table also shows that the increases in income arising from the construction phase of the project are significant. These increases are, however, temporary only, and will fall away once the construction of each plant has been completed. Nevertheless, the results suggest that a number of investment projects over a period of time could have a sustained impact on income through the construction industry.

## 5.4 Employment

The model presented above can also be used as a method of obtaining approximate employment figures. Employment can similarly be divided into direct, indirect and induced employment, where direct employment refers to permanent new workers employed on the project itself. Indirect employment refers to those new workers employed in local industries occurring in the chain of suppliers of goods and services to the project, and is assumed to occur primarily in the wholesale and retail industries. Induced employment is that which occurs as a result of sustained increases in income and, as with induced investment, is

assumed to occur primarily in the services sector.

The employment estimates presented below were calculated directly from the estimated impacts on income resulting from the two plants combined, as presented in Table 2 above. In order to calculate indirect employment, the estimated increase in permanent jobs per R 1 million contributed to GGP by the wholesale and retail industry (a value of 94) was multiplied by the net increase in income resulting from the multiplier process (that is, the multiplied increase in income less the initial investment/income). A similar process was followed in order to obtain induced employment figures: the estimated induced investment was multiplied by the estimated increase in permanent jobs per R 1 million contributed to GGP by the services sector (a value of 26)[2].

Because they are not considered to have a permanent effect on the level of employment, both direct and indirect temporary increases in employment resulting from the construction phase of the project are not included here. As induced employment is dependent on permanent changes in income, there will clearly be no induced employment effect for this phase.

Table 4 below details permanent new jobs estimated to arise from the combined project, and presents these as a percentage of the current formal sector workforce.

**Table 4. Permanent Employment Resulting from the Production Phase of the Combined Project**

| | Port Elizabeth | East London | Percentage Increase in Formal Sector Employment | |
|---|---|---|---|---|
| | | | Port Elizabeth | East London |
| Direct Employment | 750 | 750 | 0.5 | 1.18 |
| Indirect Employment | 3700 | 3676 | 2.33 | 5.8 |
| Induced Employment | 221 | 220 | 0.14 | 0.35 |
| Total | 4671 | 4646 | 2.94 | 7.34 |

As can be seen from the above table, the project has a relatively greater impact on

[2] Figures obtained from the University of Port Elizabeth's Institute for Planning Research report 55, 1993.

employment in East London than in Port Elizabeth. This is primarily a result of the smaller absolute size of the workforce in East London. In addition, while the above percentages suggest that East London would benefit more greatly from the proposed investment project that Port Elizabeth, consideration must be taken of the fact that these employment estimates assume that the necessary skills are fully available within the sub-regions. Being the smaller region, East London is characterised by fewer and smaller educational institutions (particularly those at a tertiary level) than Port Elizabeth, and is likely to be less capable of producing the necessary skills within its own region.

## 5.5 Conclusion

The theoretical results achieved in Chapter 2 are upheld in the application of this model to the proposed zinc refinery and phosphoric acid plant project in the Eastern Cape Province of South Africa. Those results suggested that in the case of two generic projects, one using relatively capital-intensive techniques with a high import content, and the other using mostly unskilled labour from within the local area, for a given initial investment, the former project would have a smaller multiplier effect on income than the latter. While the more capital-intensive project will have a higher propensity to import capital and intermediate goods and services, workers on the labour-intensive project are bound to have a higher propensity to consume and a lower import propensity. These results rested largely on the assumption that inter-industry linkages within the local "service" sector, and the consumption behaviour of service workers, were broadly similar. In addition, the results showed that by focusing on changes in permanent income, or the change in wages net of imports, the project with the greatest effect on local wages would also have the greatest effect on overall income.

In the above practical application, the impact on income in each of the sub-regions was effectively dampened by the relatively small proportion of the initial investment paid out as wages, as well as by the relatively high proportion of capital goods imported from outside the sub-regions. The considerably greater impact obtained for South Africa as a whole reflects the relatively smaller proportion of goods which are imported from outside the country.

Subsequent effects of the zinc refinery and phosphoric acid plant were more difficult to

determine. Permanent changes in local income have the potential to induce further investment aimed at expanding the existing capacity. Investment thus induced may consist of both a construction and a production phase, and it is only the latter phase that will have a lasting (induced) impact on the level of regional income or employment. In addition, induced investment may take the form of either or both, of the two generic projects described in Chapter 2, depending on the type of activity that is required by those sectors already operating at full capacity. The extent of subsequent effects will also be fundamentally influenced by such factors as the level of capacity within the economy, the sectors within which expansion takes place, the level of business confidence, availability of suitably skilled labour and so on. (Black and Saxby, 1996).

As increases in income are largely dependent on the flow of wages resulting from the project, the results obtained above may be optimised through the use of local, regional and national labour forces, as well as through use of local inputs wherever possible. In addition, the current high level of unemployment in both sub-regions, and the relatively significant impact on employment of the projects, suggests that considerable emphasis should be placed on the utilisation of local labour.

# 5. CONCLUSION

## 5.1 Purpose of the Study

Particularly in cases where impact analysis is concerned with working out aggregate impacts, it seems reasonable to inquire whether more simplified income multipliers might be used in the place of more complex models, such as the input-output model. The high costs of the considerable data required for the development of an accurate input-output model are a pragmatic justification for the use of simpler models. In regional economic analysis the simplest of all multipliers is derived from the economic base model, which can be used as a cost-effective alternative to input-output multipliers for small regional impact studies.

There also exist inexpensive methods of augmenting the economic base multiplier. One such method is the derivation of differential multipliers which approximate most of the differential multipliers derived from input-output matrices. Ultimately, the use of one model as opposed to another depends on the problem at hand, the size of the multiplier effect derived, the data available and the time and resources available to the analyst.

The aim of this study was to develop a differentiated multiplier model that would allow economic impact assessments to take account of some disaggregation in the economy, while not requiring prohibitive amounts of data. In particular, the study looked at smaller economic impact assessments, such as the impact of a new plant on the local economy of a region, where a simple, easily-adapted model can be applied at low cost.

## 5.2 General Policy Implications of The Model

The model that was developed allowed for a certain amount of differentiation, such as that between skilled and unskilled workers, and carried this differentiation through all stages of the multiplier process. This allowed the model to take account of different effects on different sectors of the economy, and has implications in terms of regional planning. For example, a project using a high proportion of imported skilled labour in a region characterised by high unemployment and primarily unskilled labour is likely to have a smaller total impact on regional income than one that makes greater use of local unskilled labour.

Alternatively, where a lack of certain skills associated particularly with a long-term project requires labour to be imported into a region, there is a clear case for producing these skills within the region, in order to optimise the potential impacts on income of the project. Investing in the development of human resources by sponsoring education in certain skills at educational institutions within the region would benefit the company proposing the project by ensuring the availability of a steady supply of workers with relevant skills within the region. Impacts on regional income of the investment project itself would also be relatively greater, as the increased use of local labour would result in a greater proportion of the income changes being retained within the region. In addition, the region would benefit from a general increase in the skill level of its workforce.

The basic difference between the regional and the national multiplier is the existence of additional leakages from the flow of income, particularly in the form of interregional imports. The model developed in this paper also took account of the leakages at every link in the production chain, thus ensuring that the multiplier operated on the actual value-added generated by a new investment project. Identifying the relevant backward linkages, and promoting those that cause fewer leakages from the region in terms of imports, can allow the multiplier effects of an investment project on the local region to be strengthened.

Finally, the model also dealt with the issue of induced investment, related to the expansion of capacity resulting from sustained increases in economic activity in a region. While many impact studies ignore this component because of the difficulty in obtaining accurate relevant

information at a sub-regional level, induced investment can add significantly to the final increase in income arising from a particular investment project. Induced investment is, however, dependent on such factors as the degree of capacity utilisation in relevant sectors, the industrial composition of the economy, and so on. More in-depth analysis of the sectoral composition of a particular region will allow more accurate estimation of where and to what extent induced investment is likely to take place.

## 5.3 Results of Application of the Model

As an illustration of the manner in which such a model could be applied, it was used to estimate the impacts of a proposed zinc refinery and phosphoric acid plant project on the local economies of the Port Elizabeth and East London sub-regions in the Eastern Cape province of South Africa. Adapting the model to the specific characteristics of the project and the region was relatively easy, since considerable data existed on a sub-regional level. Some problems were experienced in estimating import propensities, for which purposes existing input-output tables for the area had to be utilised. In addition, data relating to induced investment were difficult to obtain. However, since the model is most easily and cost-effectively applied to small regions, a number of the problems associated with insufficient data can be overcome by conducting formal or informal surveys of the area.

The project was divided into two stages: a temporary construction phase, the effects of which fall away after a period of time, and a permanent production phase, which has a sustained impact on the economy of the region. Values of the construction multipliers for both plants were 1.42 in East London and 1.44 in Port Elizabeth. Differences between the production multipliers for both plants in the two regions were even smaller; these multipliers equalled 1.343 in Port Elizabeth and 1.341 in East London. In both cases, the relatively smaller size of the East London economy - resulting in a relatively higher import propensity - was the cause of the relatively smaller multiplier values for this sub-region.

A relatively high proportion of imported capital goods for both the construction and production phase of each plant resulted in considerable leakages during the first round of the multiplier process. In addition, a relatively high proportion of expenditure on inputs, as

opposed to wages, resulted in a smaller impact on regional income than might otherwise have been experienced. The total permanent impact on income in Port Elizabeth arising from the zinc refinery amounted to R134.76 million per annum, while the phosphoric acid plant would generate a corresponding increase of R23.90 million in that region. Total permanent income changes in East London were fractionally smaller, at R134.52 million for the zinc refinery and R23.86 for the phosphoric acid plant.

The total permanent increases in income included the additional multiplied increase arising from induced investment generated by the production phase of each plant. Conservatively estimated in this study, further permanent (multiplied) increases in regional income arising from induced investment were estimated to amount to approximately R 4 million for the zinc refinery and R 0.57 million for the phosphoric acid plant. Again, differences between the two sub-regions were marginal.

The above estimates can also be made in respect of the creation of job opportunities. Permanent new jobs (arising from the production phase of the combined project) are estimated to total 4671 in Port Elizabeth and 4646 in East London. Of these total figures, 750 jobs will be created on the project itself, approximately 3700 will be created in supplying and other local industries, and about 220 will be created as a result of induced investment. Differences between the two sub-regions were once again seen to be marginal. However, presented as a percentage increase in the level of formal sector employment, the total employment creation figures were seen to have a considerably more significant impact on the East London sub-region - an increase of 7.34% as opposed to a 2.94% increase in Port Elizabeth. While these figures suggest that East London would derive a greater relative benefit from the proposed investment projects than Port Elizabeth, allowance must be made for the fact that these employment estimates assume that some of the necessary skills are available within the sub-regions.

The absolute impact of the project on the South African economy as a whole was greater than that on the economies of the two sub-regions, because of the smaller proportion of goods which are imported from outside the country, relative to the amount imported from outside the Port Elizabeth and East London sub-regions. Multipliers of 2.74 for the

construction phase, and 2.45 for the production phase were estimated, generating a total permanent increase in income of R 580.93 million (representing a 0.1% increase in GDP) for the two plants combined.

## 5.4 Impact Analysis in the Context of Regional Policy

Impact studies can give useful answers to policymakers so long as the goals of regional policy are known. For example, the application of the model developed here showed that the effects of the investment were dampened both by the small proportion of expenditure on wages, and by the high proportion of capital goods imported from outside the region. A policy goal to increase employment in the region might thus result in the rejection of this project in favour of one with a higher local input content, or one which used a greater proportion of local labour. Alternatively, such a development may be used to further the goals of regional policy, by concomitant investment in some of the supplying industries and in the development of human resources in the region.

As a final comment, it should be remembered that, at whatever level it is used, any impact assessment model is a tool, and not a substitute, for a regional development strategy.

# APPENDIX 1

# PROJECT INFORMATION[1]

## Zinc Refinery

While the local market for zinc is almost saturated, the growth in world demand for the product averages between one to two percent per annum (or 70 000 - 140 000 tpa). It is predicted that a new zinc refinery will be required every 1,5 to 2 years to meet this demand. Some international zinc plants have been expanded and upgraded, but no new plants have been built since the late 1970's. In addition, many of the existing plants are facing high labour and power costs, operate under severe environmental constraints and are no longer economically viable due to the use of outdated technologies.

The proposed refinery will make use of the latest technology in order to produce zinc at an economically appropriate scale. The situation of the refinery in the Eastern Cape Province of South Africa will be favourable for importing zinc concentrate from Australia or the Americas, and for exporting to South East Asia - currently the world's fastest growing zinc market - and to North America.

The refinery will represent an initial investment of approximately R1 500 million, and is expected to realise sales of R1 000 million with net foreign exchange earnings of R450 million annually. Initial production will be 220 000 tpa, and the plant will have a projected lifespan of 25 to 40 years. The refinery will be designed to allow for expansion to increase the capacity to 400 000 to 500 000 tpa.

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[1] All information in Appendix 1 was obtained from the "Proposal to Develop a Zinc Refinery and Phosphoric Acid Plant in the Eastern Cape: Draft Scoping Report for Comment" published by African Environmental Solutions (Pty) Ltd in August 1996.

## Phosphoric Acid Plant

Commercial grade phosphoric acid is used virtually exclusively for the production of phosphate fertilisers, which can be sold in solid or liquid forms. Smaller quantities are refined for use in other commercial applications such as beverages (colas) and household detergents. The refining process is, however, expensive, and results in specialised phosphoric acid.

While the local market for phosphoric acid in fertiliser is fully satisfied, world demand for the product is growing at 700 000 tpa. It is projected that at least one new world scale plant will be required every year to meet this demand.

Sulphuric acid, which is reacted with the phosphate rock to produce phosphoric acid, will be produced as a co-product of the zinc refining process at a rate of 400 000 tpa. Since sulphuric acid is a high-volume, low-cost substance with associated high transport costs, the phosphoric acid plant must, of necessity, be situated close to the zinc refinery. An additional synergy is that the phosphoric acid plant can use the excess steam generated by the zinc refinery to concentrate the phosphoric acid to the desired level of 54%.

The proposed phosphoric acid plant represents an initial investment of approximately R430 million. The plant will initially produce 250 000 tpa of concentrated phosphoric acid, and is expected to realise sales of R315 million annually, with net foreign exchange earnings of R104 million. The lifespan of the plant will be 25 to 40 years.

## Joint Project Information

Both the phosphoric acid plant and the zinc refinery are committed, in principle, to employing as many local people as possible, although it is possible that the main contractors may bring their own workforce with them, and that some highly-skilled employees will come from outside the region. Non-core business will be locally sub-contracted, and contractors will also be required to use local labour and resources where possible.

The construction phase of the project , which is expected to last for 24 months, is expected to

create a peak of 4 350 jobs. Some 4000 of these jobs will be on the refinery, with the remaining 350 on the phosphoric acid plant. Once these plants are fully operational, about 620 people will be directly employed on the zinc refinery and 130 on the phosphoric acid plant.

# APPENDIX 2

# ECONOMIC DESCRIPTION OF THE EASTERN CAPE PROVINCE AND THE EAST LONDON AND PORT ELIZABETH SUB-REGIONS

## Summary of the Economic Characteristics of the Eastern Cape Province and the East London and Port Elizabeth Sub-Regions

The Eastern Cape Province is one of the poorest regions in South Africa: although its Gross Geographic Product (GGP) at R26 996 million (1993 prices) is the fifth largest in the country, the region has the second highest number of inhabitants. The latest available figures show the region's 1993 per capita income level to be equal to R1359 - the second lowest of all the provinces.

The East London sub-region (population: 629 794) is defined in terms of its metropolitan (or Transitional Local Council) area definition, while the Port Elizabeth/Uitenhage metropolitan area definition is used to determine the limits of the Port Elizabeth sub-region. This broader definition of the Port Elizabeth sub-region (population: 1 061 000) is used in recognition of the importance of the Port Elizabeth/Uitenhage area in terms of economic linkages with the Port Elizabeth hinterland, with the rest of the Eastern Cape Province, and with areas beyond the provincial borders.

The sub-regional economies of these two coastal cities are relatively similar, although East London is usually seen to be secondary to Port Elizabeth in a national context. The two cities are rated as the sixth- and fifth-largest centres in the country, respectively, and 1993 figures show that the Port Elizabeth magisterial district was responsible for the major contribution (32,1%) of the Gross Geographic Product (GGP) of the Eastern Cape Province, followed by East London with a contribution of some 17,9%..

The economic base of each sub-region, represented by the percentage contribution of each economic sector to the Gross Geographic Product of the sub-region, reflects the sub-region's economic structure as well as its employment patterns. Both Port Elizabeth and East London display relatively strong secondary industries, with the manufacturing sector contributing 33% and 29,2% of the GGP of each respective sub-region. The relatively high contribution of the government sector (22.9% in Port Elizabeth and 19.2% in East London), however, suggests that the two sub-regions share a similar structural imbalance within their local economies.

Both sub-regions are also characterised by inordinately high unemployment rates, with 1994 figures showing these levels to stand at 39.8% and 38.1% of the respective labour forces of Port Elizabeth and East London. These high unemployment rates are coupled with a relatively large and active informal sector, which provides employment for a further 15.9% of the labour force in Port Elizabeth and 16.1% of that in East London. The per capita income level is marginally higher in Port Elizabeth than in East London.

## Import Propensities and Economic Linkages[2]

Some knowledge of the import propensity of a region is useful in determining the extent to which the effects of an autonomous increase in income are likely to remain within the region. However, the compilation of an accurate account of the nature and scope of a region's external trade is hampered by the fact that foreign trade is recorded only at a national level, while inter-regional trade is seldom recorded accurately. The most recent available study on economic linkages in the Eastern Cape, compiled by Hugo Nel (1993), makes use of data collected in 1985.

[2] The following information was obtained primarily from Report 53 (December 1993) released by The Institute for Planning and Research at UPE, which provides an overview of linkages within the Eastern Cape province and with other regions and provinces in South Africa.

Indications are that the structure of the economy in the province has not changed so significantly as to render these figures completely inappropriate. In addition, the concentration of economic activity in the main centres of the Eastern Cape Province (that is, the Port Elizabeth and East London metropolitan centres), suggests that the situation in the province as a whole will be largely indicative of the prevailing situation in these two sub-regions.

The Eastern Cape region as a whole displays a high import propensity, with 49.1% of total demand for all products being met by imports. Considerable leakages occur from the region in the manufacturing, construction and diverse services sectors. Some 28.4% of demand for finished goods is met by imports while 94.1 % of intermediate demand goods are imported. This suggests that the Eastern Cape region can satisfy its own final demand to a greater degree than its own intermediate demand. A large proportion of intermediate goods imported into the region in the manufacturing sector are used to produce final demand goods. The region's import propensity as regards consumption and investment goods is also relatively high.

Economic linkages refer to interdependencies between and within regions. Linkages can either be upstream (backward) or downstream (forward). Backward linkages refer to the dependency of one area (or of one sector or industry) on another as a purchaser of goods produced in the second, while forward linkages refer to the dependency of one area on another as a supplier of goods to the first area. As a result of these linkages, any exogenous change in the final demand for goods and services will have a ripple effect throughout the entire economy, affecting not only production, but also the employment of people in the relevant sectors.

Backward linkages in the region are, on average, much stronger within the region than with other regions in South Africa, with manufacturing and diverse services displaying the strongest intra-regional backward linkages. On an inter-regional basis, manufacturing and construction display the strongest linkages. This suggests that the effects of a change in final demand in the regional will be felt primarily within the region.

Most sectors in the Eastern Cape region also show stronger intra-regional, than inter-regional forward linkages. Within the region, agriculture, manufacturing, electricity, water and diverse services display the strongest forward linkages with other sectors. Despite the economy of the region being relatively open, locally produced inputs are therefore sold primarily within the region. In addition, the Eastern Cape region is less self-sufficient in terms of satisfying its demand for final goods than is the rest of South Africa.

The above factors suggest that an autonomous injection into either the East London or Port Elizabeth sub-regions is likely to be subject to considerable initial import leakages. In addition, the relatively high import propensity of the region implies that the multiplier itself is likely to be relatively small. Thus, the final change in income arising from the initial investment may not be as significant as would otherwise be expected.

The Port Elizabeth/Uitenhage (PEU) metropolitan area is a primary node both in terms of linkages within sub-regions in the Eastern Cape province, and in terms of linkages with other regions. The PEU metropole provides one of the main linkages between the Eastern Cape and the Southern Cape and between the Eastern Cape and the Border/Kei sub-region (which includes East London). The Border/Kei region does not, however, rely on the PEU in the same way that the Southern Cape does, for the primary reason that East London is in a position to supply its immediate hinterland. Despite being situated in the same province, the PEU and East London/King William's Town areas function largely as separate sub-regions

The pattern of economic linkages suggests that Port Elizabeth has relatively stronger linkages with other regions than does the East London area. Thus it appears that a stimulus to income and employment in the former area may ultimately have more far-reaching effects than the same stimulus in East London.

# APPENDIX 3

# DERIVATION OF THE PRIMARY COEFFICIENTS

Estimates of the various coefficients have been derived from a number of sources including information supplied by companies involved in the project itself, the Central Statistical Service's (CSS) Survey of Household Expenditure (1990) and October Household Survey for the Eastern Cape Region (1994), the Development Bank of Southern Africa (DBSA), and other sources detailed in the list of references. The value of these coefficients as used in our calculations of the various multipliers, are set out in Tables A.1 and A.2 below:

**Table A.1. The Values of Coefficients Relevant to the East London and Port Elizabeth Sub-Regions**

| | PORT ELIZABETH | EAST LONDON | SOUTH AFRICA |
|---|---|---|---|
| $c_u$[1] | 1 | 1 | 0.98 |
| $c_s$[1] | 0.93 | 0.98 | 0.90 |
| $t_u$[1] | 0.09 | 0.13 | 0.12 |
| $t_s$[1] | 0.33 | 0.32 | 0.33 |
| $t_i$ | 0.14 | 0.14 | 0.14 |
| $m_u$[2] | 0.49 | 0.48 | 0.07 |
| $m_s$[2] | 0.53 | 0.54 | 0.08 |
| S/T[3] | 0.09 | 0.11 | 0.17 |
| U/T[3] | 0.91 | 0.89 | 0.83 |

Notes:-

1. Estimates of consumption and tax propensities were obtained from the CSS Survey of Household Expenditure 1990

2. The import propensities for each sub-region, and for South Africa as a whole, were calculated from information obtained from the University of Port Elizabeth's Institute for Planning Research report on Economic Linkages in the Eastern Cape, 1993, compiled by Hugo Nel. This report estimated that 49.1% of total demand for all goods in the Eastern Cape Province was met by imports. This figure includes both intermediate and final demand imports, and is thus consistent with the initial import leakage used in the model, in that it incorporates leakages at all stages of the production process. The value of 49.1% was taken as a weighted average of the import propensities for skilled and unskilled workers, and these latter two values were calculated accordingly (that is, so that $m = m_s (S/T) + m_u (U/T)$, where $m = 0.491$), hence the differing values in the table. The import

propensity for South Africa as a whole clearly refers to the propensity to import foreign goods into the country. Using m = 0.07 (which figure was obtained from the same source), a similar procedure was used to calculate the relevant import propensities for skilled and unskilled workers.

3. Estimates of the division of the labour force into skilled and unskilled workers were obtained from data supplied by the DBSA on the level of education of the workforce. Skilled workers were assumed to include all members of the workforce with more than a secondary level of education.

**Table A.2. The Values of Primary Coefficients Relevant to the Zinc Refinery and Phosphoric Acid Plant**

| | ZINC REFINERY | | PHOSPHORIC ACID PLANT | |
|---|---|---|---|---|
| | Port Elizabeth and East London | South Africa | Port Elizabeth and East London | South Africa |
| Construction Stage: | | | | |
| S/T | 0.33 | 0.33 | 0.33 | 0.33 |
| U/T | 0.67 | 0.67 | 0.67 | 0.67 |
| $\alpha Q_j$ | R1725m | R 1725m | R600m | R600m |
| $m_j^*$ | 0.56 | 0.08 | 0.82 | 0.2 |
| Production Stage: | | | | |
| S/T | 0.8 | 0.8 | 0.8 | 0.8 |
| U/T | 0.2 | 0.2 | 0.2 | 0.2 |
| $(1-\alpha)Q_p$ | R695.42m | R695.42m | R193m | R193m |
| $m_p^*$ | 0.86 | 0.72 | 0.91 | 0.08 |

Notes:-

1. All information presented here was provided by the companies directly involved with the project
2. The values of $m_j^*$ and $m_p^*$ include all backward leakages as accounted for by the generic model

The above data were used to calculate the values of the weighted consumption propensities used in the multiplier model. Table A.3 below details these figures:

**Table A.3. Calculated Coefficients**

| | ZINC REFINERY | | | PHOSPHORIC ACID PLANT | | |
|---|---|---|---|---|---|---|
| | Port Elizabeth | East London | South Africa | Port Elizabeth | East London | South Africa |
| $c'_u$ | 0.34 | 0.33 | 0.68 | 0.34 | 0.33 | 0.68 |
| $c'_s$ | 0.20 | 0.21 | 0.47 | 0.20 | 0.21 | 0.47 |
| $c'_j$ | 0.29 | 0.29 | 0.61 | 0.29 | 0.29 | 0.61 |
| $c'_p$ | 0.23 | 0.23 | 0.51 | 0.23 | 0.23 | 0.51 |
| $c'_d$ | 0.33 | 0.31 | 0.65 | 0.33 | 0.31 | 0.65 |

## Induced Investment Coefficients

Calculation of the coefficients relevant to the estimation of induced investment (see Table A.4 below) was problematic, as very little relevant data exists on a national, let alone on a regional or sub-regional, level. Following Brownrigg (1971) and Bleaney et al (1992), a basic assumption was made that induced investment is likely to occur in the services sector. An induced investment project is itself likely to be made up of a temporary (construction) and a permanent (operational) component, both of which are subject to an initial leakage, $m_j^*$ and $m_n^*$, respectively. These variables were estimated using the total import propensities for these two sectors in the Eastern Cape Province.

Where specific data was lacking, the relevant coefficients from the original project were substituted, as in case of the weighted consumption propensities (not detailed here). This, of course, resulted in the multiplier for the additional permanent increase in income resulting from induced investment being equal to that for the permanent stage of the original project . Had data been available on the division of the labour force into skilled and unskilled workers in the relevant services and construction sectors in each of the two sub-regions, a more accurate multiplier for induced investment could have been estimated. In the table below, only the multiplier for the permanent stage of the induced investment project, $k_n$, is represented, as it is only this permanent phase which gives rise to further permanent increases in income.

The values of $\beta$ and $(1-\beta)$ below represent the proportions of induced investment expenditure

which are likely to be directed at the temporary and the permanent components of the induced investment project, respectively. In the absence of suitable data, the proportions of investment expenditure on the temporary and permanent components of the original projects have been used as a proxy.

The value of the induced investment coefficient is typically extremely difficult to estimate with any degree of accuracy. The estimation of this variable depends on the degree (if any) of excess capacity (particularly in the services sector), the various lags involved in consumers' expenditure and suppliers' reaction, and the size and industrial structure of the region. Brownrigg (1971) estimates a value of 2.4, based on average statistics for the United Kingdom, and assuming fully utilised capacity in the area under study, and a considerable immigration inflow to that same area. Figures provided by the Central Statistical Service (CSS) show that productive capacity utilisation for the manufacturing sector in South Africa as a whole, stood at some 80.2% in February 1996. Coupled with the low employment rates for the Port Elizabeth and East London local economies, and the low levels of business confidence in South Africa generally (which may have the effect of increasing response times on the part of producers), this suggests that the induced investment coefficients in these sub-regions is likely to be substantially below Brownrigg's estimate. In the absence of more accurate and relevant data, the induced investment coefficient was thus guestimated conservatively at 10%.

## Table A.4. Induced Investment Coefficients

| | ZINC REFINERY | | | PHOSPHORIC ACID PLANT | | |
|---|---|---|---|---|---|---|
| | Port Elizabeth | East London | South Africa | Port Elizabeth | East London | South Africa |
| n | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 |
| $m_j^{*1}$ | 0.46 | 0.46 | 0.043 | 0.46 | 0.46 | 0.043 |
| $m_n^{*1}$ | 0.43 | 0.43 | 0.083 | 0.43 | 0.43 | 0.083 |
| $\beta^2$ | 0.6 | 0.6 | 0.6 | 0.68 | 0.68 | 0.68 |
| $(1-\beta)^2$ | 0.4 | 0.4 | 0.4 | 0.32 | 0.32 | 0.32 |
| $k_n$ | 1.34 | 1.34 | 1.34 | 1.34 | 1.34 | 1.34 |

Notes:

1. Estimates of import propensities were obtained from the University of Port Elizabeth's Institute for Planning Research report on Economic Linkages in the Eastern Cape, 1993, compiled by Hugo Nel. The figures represent the percentage of total demand satisfied by imports (both intermediate and final imports) in the construction and manufacturing sectors in the Eastern Cape region. These figures are thus consistent with the import propensities presented in the original multiplier, in that they incorporate leakages at all links in the production chain.
2. The proportion of induced investment expenditure directed towards permanent and temporary components of induced investment projects is assumed to be the same as that of the original projects.

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