CHAPTER 6

INTRODUCTION TO AN APPLIED GENERAL EQUILIBRIUM MODEL[1]

6.1   INTRODUCTION

The previous chapters have indicated that analysis of the effect of environmental taxation on the South African economy will be best served within a general equilibrium framework. Studies in this regard were analysed in previous chapters and the models briefly described. The purpose of this chapter is therefore to analyse the concept of general equilibrium modelling. The analysis will serve as an introduction to the two chapters that follow this one, which describe a general equilibrium model of the South African economy. This model will eventually be applied to analyse a proposed revenue neutral tax on the use of coal in South Africa.

6.2   INTRODUCTION TO GENERAL EQUILIBRIUM THEORY

The concept of general equilibrium modelling has developed over the past two centuries. Adam Smith's description of the behaviour of capitalists, motivated by considerations of profitability in the selection of economic activities, and John Stuart Mill's treatment of international trade and agents' responses to changes in taxes and import duties, can be viewed as the source of inspiration for this type of modelling framework. However, work by Leon Walras in 1854 allowed general equilibrium modelling to reach a mature form when he provided a general description of the functioning of a complex economic system based on the interaction of a number of interdependent economic units. Walras' work was expanded, and solutions to some of the caveats in his formulations of a general equilibrium were provided by the increase in activity in mathematical economics that took place in the 1940s and 1950s under mathematical economists such as Arrow (1954) and Debreu (1954). The most significant contribution by mathematical economists was in the mathematical confirmation of the consistency of the general equilibrium model (Scarf *et al*, 1984, pix).

In the text describing their general equilibrium model for the US economy, Ballard *et al* (1985) introduce the usefulness of this type of model by stating: "*Many questions of economic policy can be analysed within a partial equilibrium framework. When policy changes being considered are relatively small, it may be appropriate to neglect general equilibrium interactions among many*

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[1] This chapter serves as an introduction to general equilibrium modelling for readers that are not familiar with the concept of general equilibrium modelling.

different markets. However, when large policy changes are considered, partial equilibrium analysis becomes painfully inadequate. In recognition of this fact, a vast increase has occurred in the past twenty years in the number of economists who use general equilibrium models" (Ballard *et al*, 1985, p1)

Scarf and Shoven (1984) expand on this description by stating that one of the virtues of the general equilibrium model is its ability to trace the consequences of large changes in a particular sector throughout the entire economy. A general equilibrium model is therefore an expansion of input-output analysis in that it permits a more flexible treatment of the consumer side of the economy and is less rigid in the requirements that it places on the production side. This confirms the statement of Ballard *et al* (1985): "*The consequences of a change in economic policy are frequently analysed by assuming the changes to be small and using local linear approximations based on estimates of the relevant elasticities. If the sectors are small, diagrammatic techniques or explicit analytical results may also be available as in the two-sector models so frequently used in international trade theory. But if the model is disaggregated, and if changes – possibly more than one – are large, there is no recourse other than the construction and explicit solution of a numerical general equilibrium model.*" (Scarf *et al*, 1984, pxi).

Scarf *et al* (1984) also mention the imperfections of a general equilibrium model. General equilibrium models have difficulty in allowing for money and financial institutions, they have difficulty with the incorporation of unemployed resources into their frameworks and are unable to cope with large-scale industrial enterprises that are capable of exerting significant pricing power on an economy. However, there are currently no competing formulations that can avoid these short-comings and until economic theory is capable of providing compelling alternative formulations, general equilibrium modelling will retain its usefulness.

It is therefore hardly surprising that general equilibrium models have been used to analyse policy issues such as:

i.   changes in tariffs, exchange rates and other trade;
ii.   changes in tax policy;
iii.   changes in energy prices or environmental and energy policies, and
iv.   changes in the development process.

6.3   A DESCRIPTION OF GENERAL EQUILIBRIUM MODELLING

A general equilibrium model is an economic model, based on the underlying economic theory of general equilibrium. According to Mansfield (1991, p414), a state of general equilibrium is a state in which the following conditions hold:

i.   Every consumer chooses a consumer basket subject to a budget constraint, which is determined by the prices of inputs and the prices of products.

ii.   Every consumer supplies whatever amount of inputs he or she chooses, given the inputs of product prices that prevail.

iii.   Every firm maximises profits subject to a budget constraint imposed by the available technology, the demand for its product, and the supply of inputs in the long run. However, economic profits are zero.

iv.   The quantity demanded equals the quantity supplied at the prevailing prices in all product and input markets (Mansfield, 1991, p 414).

Shoven and Whalley (1984, p1009) confirm the above conditions by summarising a general equilibrium as a state in which all markets clear. This is supported by Varian's (1993, p282) comments that, in a general equilibrium, all prices are variable, and equilibrium requires that all markets clear. The existence of such a state in the economy was first proven by Leon Walras.

From Walras' work it has been shown that:

i.   an equilibrium set of prices will only exist if there is no good for which there is positive excess demand (Walrasian equilibrium);

ii.   for any set of equilibrium prices the value of the excess demand is identically zero (Walras' law);

iii.   if demand equals supply in k-1 markets, and the price of the good in the kth market is positive, then demand must equal supply in the kth market;

iv.   if a set of prices results in Walrasian equilibrium and some goods are in excess supply at this equilibrium, it must be a free good (Varian, 1993, p493).

From the above it seems as if a feature of a general equilibrium model is that a set of prices, levels of production and consumption exist in each industry and household, so that market demand equals supply for all commodities.

A very descriptive summary of what a general equilibrium model entails is given by Scarf (1984). According to him, the fundamental theme of a general equilibrium model lies within the heart of economic theory. The production side of the economy, engaged in the transformation of certain commodities into other commodities, is distinguished from the consumption side, whose goals are the acquisition and eventual consumption of goods and services. Households' own stocks of commodities, may be consumed directly, maintained as inventories for eventual use, or offered as factors of production in a physical form, or by means of a variety of financial instruments. A consumer's income or wealth is determined by evaluating his stock of commodities in terms of those prices at which the commodities can be sold. Income and knowledge of relative prices permit the consumer to express his demands for goods and services as well as his offerings of labour and other stocks that are made available for the productive side of the economy. The decisions of the production and consumption sides of the economy need not be consistent with each other if they are based on an arbitrary set of prices. If the prices of a desired commodity are too low, consumers may be motivated to demand large quantities of this commodity, and producers may be averse to supplying that commodity, of which sales generate insufficient revenue to cover the costs of manufacturing the commodity. Equilibrium prices are therefore those prices that equate demand and supply in all markets. Once these prices are known, economic decisions are made based on them (Scarf, 1984, p1-3).

6.4 FROM A GENERAL EQUILIBRIUM MODEL TO A COMPUTABLE GENERAL EQUILIBRIUM MODEL

A computable general equilibrium model (CGE) is nothing more than a general equilibrium model that can be used to provide quantitative analysis of economic policy problems. A CGE model therefore also needs, apart from the theoretical structure provided by a general equilibrium model, some data concerning the economy of interest. Once the general equilibrium model and data have been integrated, an actual solution method needs to be determined in order to solve the equilibrium prices and decision variables in the equilibrium system. (Dixon *et al*, 1991).

The development of an applied general equilibrium model typically includes the following steps:

i. Development of the theoretical general equilibrium model which consists of:
- Equations representing household and other final demands for commodities.
- Equations for intermediate and primary factor inputs.

- Pricing equations relating commodity prices to costs.

- Market clearing equations for primary factors and commodities.

ii.   Use of input-output data to provide estimates for the relevant cost and sales shares.

6.5   CONCLUSION

From the above description of the nature and use of general equilibrium models, it has been shown that this type of model is based on the underlying assumption of the existence of a set of prices that allows for market clearing. General equilibrium models have widely been used in policy analysis that covers almost every field of economics, ranging from international trade theory to taxation and environmental issues. The advantage of these models lies within their ability to analyse the effect of large policy changes on the economy as a complete system of interdependent variables. However, given the above advantage, general equilibrium models have a number of imperfections. These include difficulty in allowing for unemployed resources and problems with allowing for large-scale enterprises that are capable of exerting significant influence on prices. However, because of the lack of competing formulations that are capable of providing the same amount of analytical power, this type of analysis will retain its usefulness until economic theory provides compelling alternative formulations.