CHAPTER 4

THE DOUBLE DIVIDEND HYPOTHESIS

4.1 INTRODUCTION

Although they are not a favourite among policy makers, environmental taxes have rested on an academic pedestal since they were first proposed by Arthur Pigou in his Economics of Welfare (1920). Pigou argued that taxing polluting emissions would reduce pollution in the most efficient manner possible. Neither Pigou nor anyone else ever seriously considered the possibility that such taxes would introduce new distortions into the economy. Recent research indicates, however, that the distortions associated with environmental taxes could be quite significant. It is also possible that traditional environmental policy instruments, such as tradable permits, could introduce similar distortions.

Along with new research on the distortions of environmental taxation, a new body of economic research has come to the fore, which is based on the fact that environmental taxes provide revenues. It is argued that revenue from environmental taxes can be used to reduce existing market distortions that are caused by an inefficient tax system. This argument has resulted in a policy debate that focuses on the potential "double dividend" that can be reaped from an environmental taxation policy. David Pearce (1991) is among the early proponents of the double dividend hypothesis, which proposes that the introduction of an environmental tax should be accompanied by a revenue-neutral decrease in a pre-existing distortionary tax. In his seminal article published in 1991 Pearce argues:

"*While most taxes distort incentives, an environmental tax corrects distortion, namely the externalities arising from the excessive use of environmental services. A carbon tax would be set on the basis of the carbon content of fossil fuels. Given the widespread use of fossil fuels, any tax would inevitably be revenue raising, even though the tax works best if it is avoided through the introduction of low or zero carbon technologies. Governments may then adopt a fiscally neutral stance on the carbon tax, using revenues to finance reductions in incentive–distorting taxes such as income tax, or corporation tax. This "double dividend" feature of a pollution tax is of critical importance in the political debate about the means of securing a "carbon convention"*
(Pearce, 1991, p940).

Pearce (1991) proposes that the revenue that is raised from an environmental tax should be returned to the economy by decreasing a pre-existing distortionary tax. The benefits of such a policy would result in a double dividend, namely:

i. *The environmental dividend*: a reduction in the environmental damage caused by pollution externalities.
ii. *The tax dividend*: a reduction in the distortion of the overall tax system due to the reduction in a specific distortionary tax.

Although there is widespread agreement on the benefits that accrue to an improvement in the environment (first dividend), the magnitude of these benefits in terms of the welfare of society are uncertain and difficult to quantify. Attention has therefore been directed towards proving the existence of the second dividend. If it can be shown that the implementation of an environmental tax will result in a positive tax benefit (or at least a zero tax cost), then a policy that introduces an environmental tax should appeal to policy makers, as the net result of both dividends will be positive. However, the opposite also holds. If the benefits of the second dividend are shown to be negative, it will be difficult to propose an environmental tax policy, given the uncertainties regarding the magnitude of the first dividend. It is therefore not surprising that the notion of a double dividend has become increasingly popular with environmental groups, which argue strongly in favour of a positive second dividend. Apart from its appeal to policy makers, Pearce (1991) also argues that the notion of a double dividend could serve as a mechanism to persuade the developing world to sign up for international agreements to reduce CO_2 emissions. The importance of this mechanism is highlighted by the fact that fossil fuels contribute significantly towards the development process and that few developing countries would agree to reductions if a positive benefit could not be attained, regardless of the environmental concern (Pearce, 1991, p941).

Because of its appeal to policy makers, several papers have explored the possible existence of the double dividend. Most of the theoretical work has been unable to achieve clear-cut conclusions. Papers have often emphasised the restrictive conditions that need to be satisfied within a particular market for the double dividend to be attained (Carraro *et al*, 1995, p74). The reason for this ambiguity stems from the well-known economic principle that taxes distort economic behaviour. Environmental taxation is no exception.

4.2 DEFINING A DOUBLE DIVIDEND

In order to obtain a thorough understanding of the literature concerning the double dividend hypothesis it is necessary to clarify and define this notion properly.

Goulder (1994) essentially identifies three forms of the double dividend. These three forms are briefly described below.

4.2.1 The weak form of the double dividend

A weak form of the double dividend hypothesis postulates that by using revenues from an environmental tax to finance reductions in marginal tax rates of an existing distortionary tax, the economy will achieve cost savings relative to the case where the tax revenues are returned to taxpayers in lump-sum fashion. According to Goulder (1994), this form of the double dividend has been uncontroversial and should hold, given that a lump-sum redistribution of tax revenue will be inefficient relative to a distribution of tax revenue through a reduction of existing (inefficient) marginal tax rates. The only exception to this would be where the existing marginal tax rate is already negative. In this case, a further reduction of the tax rate would actually increase the inefficiency (Goulder, 1994, p4).

According to Miller (2001, p2), the weak form of the double dividend is nearly unambiguous, but does not have much power. A net negative benefit to the economy, which could arise from the market distortions (caused by the implementation of an environmental tax), is still possible. Apart from the above description of the weak form of the double dividend, Hansen (1999, p5) confirms the above description by stating that the allocation of revenue from environmental taxes towards the reduction of other distorting fiscal taxes will be a welfare improvement above returning revenues to tax payers in a lump-sum fashion. This argument implies that there is a welfare gain if revenue from those environmental taxes that are imposed is allocated towards general expenditures or tax cuts, rather than earmarked for recycling by polluters or for environmental expenditures.

Although the weak form of the double dividend hypothesis seems uncontroversial, it does not give much power to motivating the introduction of an environmental tax and only concerns itself with the manner in which the revenue that is raised from such a tax is redistributed. The “strong forms” of the double dividend definition is more controversial and defines a more narrow benefit that can be attained from environmental taxation.

4.2.2 The intermediate and the strong forms of the double dividend

According to Goulder (1994), the strong forms of the double dividend hypothesis postulate that by swapping an environmental tax for an existing distortionary tax, the economy will reap positive benefits (negative costs) through the increase in social welfare. These results are usually obtained, because inefficiencies of the existing tax system are reduced by the recycling of revenue from the new (more efficient) tax. A distinction is made between two forms of this double dividend, namely:

i. The "intermediate form" of the double dividend postulates that there exists at least one tax for which the strong form of the double dividend hypothesis applies.

ii. The "strong form" of the double dividend implies that the double dividend hypothesis holds for typical taxes.

The stronger form differs from the intermediate form only in that the stronger form is postulated for a representative distortionary tax, while the intermediate form is postulated for some distortionary tax. Both these forms claim that the gross costs of the tax reform are negative. The gross costs can be separated into the cost of the environmental tax and the cost of an equal-revenue change in the distortionary tax. Both the intermediate and the strong forms claim that the first cost is always smaller than the second (Goulder, 1994, p7).

Hansen (1999, p5) adds to the definition of the strong form of the double dividend by postulating that environmental taxes carry a strong double dividend (in addition to gains from Pigouvian price signal corrections) because the implied broadening of the tax base in itself is welfare improving. Therefore, under this form of the double dividend hypothesis, the introduction of environmental taxes will be welfare improving even if the environmental effect is negligible. As the following sections will illustrate, Hansen's argument in favour of the strong form does not seem to hold, as an environmental tax usually results in a decrease in the tax base of a country, especially where it is used to finance decreases in distortionary taxes such as the tax on labour.

Because the strong forms of the double dividend entails a positive benefit that arises from the reduction in the marginal tax rate on other factors of production, focus has shifted towards determining the conditions under which such a dividend will exist. As already noted, the existence of a strong form of the double dividend hypothesis will increase the popularity of an environmental policy with policy makers, as it will only be necessary to make the very plausible assumption that

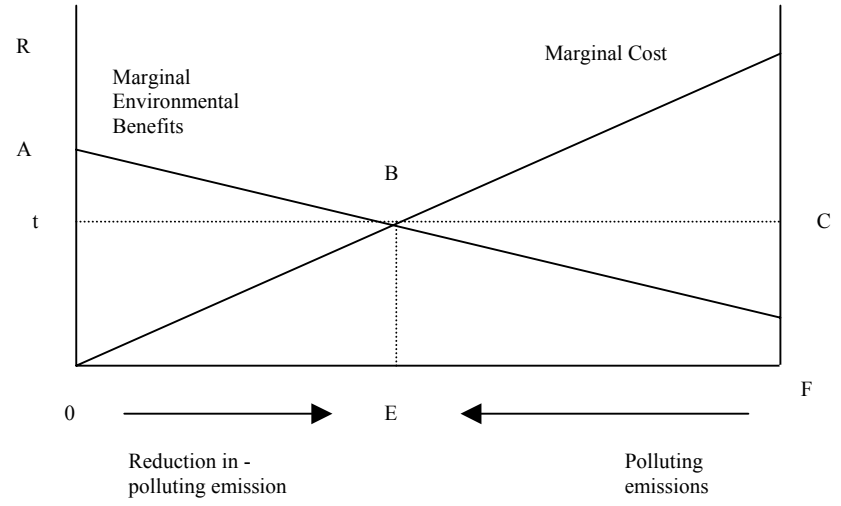
an improved environment will have a positive welfare effect on a society. The magnitude of this effect is, however, of no relevance once the existence of a second dividend can be proven.

The above definitions of the different forms of the double dividend indicate why the existence of a double dividend can be so appealing to environmental groups and policy makers. Even though the existence of a double dividend is easy to prove within a partial equilibrium framework, subsequent general equilibrium analysis has resulted in a much broader debate around this topic. Although still not clear-cut, recent research has shown that the strong form of the double dividend can only be obtained under very specific circumstances.

4.3 THE DOUBLE DIVIDEND UNDER PARTIAL EQUILIBRIUM ANALYSIS

Within a partial equilibrium framework, analysis of the effect of an environmental tax on the economy indicates a net welfare gain for society if the revenue is returned to the economy by reducing marginal taxes on factors of production. The following analysis provides an example of a partial equilibrium approach to the double dividend hypothesis.

Figure 4.1: Partial equilibrium analysis of the effect of an environmental tax on the welfare of society.



Source: Parry *et al*, 1995

The first welfare gain that society obtains from an environmental tax is the triangle OAB that results from internalising the external effect (or social cost) of polluting emissions. In this case is due to a unit tax of 0t on emissions. According to Parry *et al* (1998), in an analysis where environmental

revenues are returned to economic agents in a lump sum, this environmental benefit is the only concern of policy makers. However, in the presence of pre-existing tax distortions, an additional concern can be addressed. In this case, the revenues that are raised by the environmental tax (EBCF in the figure) can be used to reduce the rates on existing distorting taxes. This should result in a second welfare gain, which is popularly known as the revenue recycling effect. In the case where the distorting tax is a tax on labour, the welfare gain should arise from the reduction of the difference between the gross and net wage, which should result in an increase in employment. The combination of the first and second gains in welfare is equal to the existence of a double dividend (Parry *et al*, 1998, p9).

Although the results of a partial equilibrium analysis seem positive for the attainment of a double dividend, such analysis seems inadequate. Pearce (1991) refers to the need for a general equilibrium analysis of the double dividend hypothesis because carbon taxes themselves will impose a deadweight loss, which has to be set against the gain from the reduced externality of global warming. A partial equilibrium approach can therefore, at best, indicate the effect of "small" carbon taxes on economic welfare (Pearce, 1991, p943).

This "concern" with partial equilibrium analysis became apparent in 1994 when Lans Bovenberg and Ruud De Mooij published a paper in which they made use of a general equilibrium approach to indicate that a simple partial equilibrium analysis of the double dividend hypothesis omits significant second order effects that pertain to the consequences of the interaction between the new environmental tax and existing distortionary taxes. Since this paper, numerous studies have been performed that made use of general equilibrium analysis to indicate that the introduction of an environmental tax brings about a tax interaction effect that could aggravate existing tax distortions. This tax interaction effect could be larger than the positive effect that arises from the revenue recycling effect. If this is the case, the tax interaction effect will render the second dividend from an environmental tax negative.

4.4 THE DOUBLE DIVIDEND UNDER GENERAL EQUILIBRIUM ANALYSIS

As indicated above, the first influential researchers that made use of a general equilibrium analysis to evaluate the double dividend hypothesis were Bovenberg and de Mooij (1994). They analysed the existence of the strong form of the double dividend within a general equilibrium model. Subsequent research on the topic of the attainment of the double dividend focused on the relaxation

of some of the assumptions of their model. The theoretical model that Bovenberg and De Mooij utilised is based on the following simplifying assumptions:

i. A closed economy in which two goods are produced: a "clean" product and a "dirty" product. The consumption and production of the "dirty" product result in an increase in pollution.
ii. Labour is the only factor of production and labour pays an income tax.
iii. Utility is obtained by consumption of both the "clean" and the "dirty" products and the enjoyment of leisure. An increase in the utility of a household postulates an increase in welfare.
iv. The production function exhibits constant returns to scale.

Within this model the introduction of an environmental tax and the subsequent reduction of marginal tax rates on labour did not result in a double dividend (positive welfare benefit). In fact it was found that the introduction of an environmental tax could actually increase the inefficiency associated with existing distortionary taxes. The intuition behind the finding is that the general equilibrium effects associated with the introduction of an environmental tax introduces tax interaction effects that negate the benefit from the revenue recycling effect. These affects have been disregarded by partial equilibrium models. In a general equilibrium setting the effect of an environmental tax is to increase the cost of production. To the extent that this cost is passed on to consumers, it will reduce the real wage that is received by households. As a result of the decline in the real wage, the return to work effort declines and less labour is supplied. This results in a fall in employment and a reduction in overall welfare. Furthermore, the tax also distorts the choice among consumption goods, which adds to the gross cost of the environmental tax. It can therefore be deduced that environmental tax swaps will increase rather than decrease the efficiency cost of pre-existing tax distortions (Goulder, 1994, p10).

Apart from serving as an additional tax on factors of production, Bovenberg and de Mooij (1994) found that by recycling environmental taxes (revenue recycling effect) the tax base is eroded, as taxation is shifted from the broader based labour income tax to selective environmental taxes. This reduces the tax base, and if the government wishes to maintain unchanged tax revenues it will be unable to cut labour taxes to the extent that it compensates workers for the erosion of their after-tax real wage stemming from higher environmental taxes. As a result, employment decreases (rather than increases) as a consequence of environmental tax reform.

Subsequently these findings have been confirmed by other studies which used general equilibrium analysis to test for the existence of a strong form of the double dividend. These studies have indicated that by introducing an environmental tax into a system in which distortionary taxes already exist, three effects need to be considered to evaluate the existence of a positive second dividend. These are:

i. *The primary cost of the environmental tax*: this is the direct cost to the regulated sector's need to reduce pollution through changes in production methods or installation.
ii. *Revenue recycling effect*: this effect requires a general equilibrium analysis but should, in general, serve to lower the cost of tax reform.
iii. *Tax interaction effect*: this effect also requires a general equilibrium analysis and usually counters the revenue recycling effect. Generally it shows how the new tax increases producer costs, which implies higher prices for commodities, and reduces the real income of factors of production. The tax interaction effect usually implies that the environmental tax functions like an increase in factor taxes, adding to the distortion in factor markets arising from existing taxes (Goulder, 1994, p11).

With few exceptions, most studies find that the costs from this interaction effect dominated any efficiency benefits from recycling environmental tax revenues by reducing other distortionary taxes.

From the above it is clear that the theoretical requirement for obtaining a double dividend from an environmental tax is that the revenue recycling effect should outweigh both the primary cost and the tax-interaction effect of the environmental tax. However, there is strong evidence that the revenue recycling effect is not strong enough to outweigh the other two costs, and in some cases, the revenue recycling effect is weaker than the tax interaction effect alone. In these cases the gross cost of the environmental tax not only fails to be negative, but turns out to be higher than it would be in a world without prior distorting taxes where the revenue recycling and tax interaction effects are absent. This attests that environmental taxes are actually implicit factor taxes that compound existing factor market distortions.

Carraro *et al* (1995) complement the above findings by identifying three main mechanisms that frustrate attempts to increase employment within a double dividend setting. According to the authors, these three mechanisms have become prominent from applied work on the double dividend hypothesis. The mechanisms are:

i. The effects of energy taxes on the tax base. If the substitution effects induced by the tax (factor substitution, product substitution, technical progress) are such that they shrink the tax base, the revenue to be recycled may be very low (substitution effect). According to Carraro *et al* (1995), the revenue may be even lower if the tax induces a contraction of economic activity (income effect).

ii. The second effect relates to the expenditure side of the government budget. If the tax has an impact on product prices, the increased inflation rate increases nominal interest rates, which worsens the debt burden of the government (debt effect). In countries where the public debt is high, the increased expenditure for interest payments may significantly reduce environmental tax revenue.

iii. The third mechanism is directly linked to the functioning of the labour market. In particular, this mechanism is concerned with the possibility that tax revenue, whenever it exists, may not reach the desired objective. This will particularly be the case in a labour market where wages are dependent on bargaining between unions and employers. The experience in Europe has been that a reduction in payroll taxes would increase the net wage and reduce the gross wage. In the long-run, all changes of the fiscal wedge are exactly off-set by changes in the net wage. This will leave employment unchanged. On the other hand, if the elasticity of the net wage with respect to the fiscal wedge is low, employment increases and the net wage increases, thus increasing consumption and, more generally, aggregate economic activity. This effect brings about an increase of energy consumption and emissions. Therefore, whenever the employment objective is achieved, the environmental one may be lost (Carraro *et al*, 1996, p74).

Based on the above, existing research indicates that the existence of a double dividend is questionable once the general equilibrium effects of the proposed environmental tax are considered. There are, however, some cases in which the revenue recycling effect could outweigh the tax interaction effect. These cases appear more plausible when some of the simplifying assumptions from the Bovenberg and De Mooij (1994) model are relaxed.

4.5 REQUIREMENTS FOR ATTAINING THE SECOND DIVIDEND

Although the Bovenberg and de Mooij (1994) model indicates that the existence of a double dividend could be difficult to obtain, Goulder (1994) and Goulder *et al* (2000) summarise a few conditions under which the Bovenberg and de Mooij results could be altered to obtain a double dividend. Goulder (1994) analysed possible extensions to the simple Bovenberg and De Mooij

(1994) model and showed that different extensions could alter the evidence with regard to the strong form of the double dividend. The extensions that Goulder examined are briefly discussed below.

i. The inclusion of intermediate inputs in the production function

According to Goulder (1994) the inclusion of intermediate inputs in the production function should not result in a strong form of the double dividend. The argument in this regard is the same as with a tax on the production of a polluting product. An environmental tax on intermediate inputs, which result in pollution, will also cause producer costs to rise. This increase in producer costs will be passed on to the consumer, which should result in a decrease in real income and reduce the incentive to provide labour. The net effect is a welfare loss to households and society (Goulder, 1994, p12).

ii. The inclusion of capital in the production function

According to Goulder (1994), two considerations are important when assessing the importance of including capital in the analysis:

- The extent to which the marginal efficiency costs of capital taxation differs from those of labour taxation before the introduction of an environmental tax. Here the factors on, which these marginal efficiency costs depend, need to be taken into consideration. Labour taxes distort the labour-leisure margin (therefore a function of labour elasticity of supply and marginal tax rate), while capital taxes distort the margin of choice between consuming today and consuming in the future (therefore a function of the intertemporal elasticity of substitution in consumption and marginal capital tax).
- Whether the burden or incidence of the environmental tax falls largely on labour or capital. An example would be an environmental tax that falls mainly on consumption commodities. The burden of such a tax will mainly fall on labour. However, the burden of an environmental tax that affects the production of investment commodities will fall mainly on capital (Goulder, 1994, p14).

These two considerations will cause the costs of the environmental tax to be lower if:

- The difference in the marginal excess burdens of the initial tax systems is large.

- The burden of the environmental tax falls primarily on the factor with relatively low marginal efficiency cost.
- The base of the environmental tax is relatively broad, so that the distortions it generates in the intermediate good and consumer markets are small.
- Revenues from the tax are devoted to reducing tax rates on the factor with relatively high marginal efficiency cost (Goulder, 1994, p15).

Goulder (1994) also states that if the above considerations do in fact exist within an economy, the environmental taxation could result in an intermediate or strong double dividend. An example of these conditions is in the USA where the marginal excess burden on capital is much higher than the excess burden on labour. Therefore, if a tax on consumption of fuel was to be introduced, it should result in a relative increase in the tax burden on labour if the revenue is used to decrease the burden on capital. The results are, however, reversed if the tax were to be introduced on intermediate inputs, as this would ultimately be borne by capital and increase the excess burden relative to labour (Goulder, 1994, p16). Therefore, it seems that introducing capital into the model could only result in a strong form of the double dividend if inefficiencies exist within the existing tax system (Goulder, 1994, p17).

iii. The existence of subsidies on the production of a polluting good

From economic theory it is known that subsidies on the production and consumption of goods introduce inefficiencies and welfare costs into an economy. If subsidies on the production or consumption of polluting goods exist, an environmental tax could be used to eradicate the effects of the subsidy and subsequently result in a strong form double dividend. It can, however, be argued that the eradication of the subsidy could be achieved without the environmental tax, which should result in efficiency gains for the economy, independent of an environmental tax (Goulder, 1994, p17).

iv. Introducing an argument of exhaustible resources and decreasing returns

According to standard economics on natural resource taxation, an environmental tax should not result in an alteration of the intertemporal allocation of these resources, nor should it have any efficiency cost because natural resources are an exhaustible input or commodity. However, according to Goulder this would not necessarily result in the existence of a double dividend, as an environmental tax is usually not raised on scarcity rents, but rather on the quantity produced, and

therefore introduces an efficiency cost (affects intertemporal choice). The reason is that the quantity of the resource that is used is the result of a combination of labour, capital and natural resource inputs. Therefore, although the environmental tax will not have an efficiency cost on the natural resource input, it will have an effect on the efficiency of labour and capital. Distinguishing the efficiency cost to each of these factors is, however, a difficult exercise, and the efficiency cost on capital and labour should still have a considerable tax interaction effect (Goulder, 1994, p18).

v. Introducing involuntary unemployment into the model

A general assumption in general equilibrium models is that all markets clear and unemployment should therefore not exist. However, introducing a fixed wage above the market-clearing wage does not result in a strong form of the double dividend. The reason is that the introduction of an environmental tax decreases labour productivity and shifts the labour demand curve to the left. This result should hold, regardless of the existence of a fixed wage (Goulder, 1994, p19).

Bovenberg and van der Ploeg (1996) indicate, however, that in the case where there is involuntary unemployment while capital remains fixed, an environmental tax results in a tax shift from labour towards the immobile factor of production. This can result in a double dividend if labour is already inefficiently taxed (Bovenberg et al, 1996, p79).

vi. Introducing the environment as a capital good

Most models only include the environment as a consumption good. However, environmental quality could be included as a capital good within the production function. This allows a cleaner environment to contribute positively to production, if all other factors are held constant. The problem with this approach is the separation of the costs and benefits of tax policies towards welfare, once the environment is included within the production function. The distinction between the costs (benefits) of a cleaner environment and the costs that arise from the tax revenue effect is important in proving the double dividend hypothesis (Goulder, 1994, 20).

vii. Introducing an open economy and the terms of trade effect

An environmental tax on a polluting good could result in an improvement in the terms of trade if the country which raises the tax is a net importer of the good and has enough market power to change the world price of the good. By taxing the imported good the economy reduces national (and therefore global) demand for the good and reduces the good's price before taxes in the world market. This shifts some of the burden of the environmental tax onto foreigners if the revenues from the tax are devoted to cutting taxes paid by domestic consumers or domestically owned firms. According to Ethier (1995) such an argument is strictly a nationalistic one, and with such a policy the domestic economy imposes a loss on the rest of the world that exceeds the domestic economy's gain (Ethier 1995, p224).

By allowing for the above extensions to the Bovenberg and De Mooij model of 1994, Goulder (1994) indicates that in most cases inefficiencies within the tax system should already exist before the existence of the strong form of the double dividend can be obtained. The only exception is where a country can obtain terms of trade benefits by implementing the environmental tax.

Goulder *et al* (2000) adds to the above by showing that more complex general equilibrium models, as well as larger numerical models, offer scope for the existence of the strong form of the double dividend by allowing additional potential channels for beneficial efficiency impacts. These channels include:

i. A model, which allows the polluting good to be a weak substitute for leisure

A strong double dividend could arise if the polluting good is a weak substitute for leisure. The efficiency loss from the tax interaction effect will be smaller. In fact, when the polluting good and leisure are complements, the efficiency of the tax interaction effect should increase. That is, by making the polluting good more expensive, less leisure will be enjoyed and more labour supplied. This could, however bring about a decrease in utility if leisure is inductive to an increase in utility. On the other hand, taxing goods that are relatively strong substitutes for leisure would increase efficiency costs. In such a case, instead of enjoying more of the polluting good, the higher price of the polluting good should induce labour to substitute it for leisure. This will result in a decrease in labour supply and a reduction in welfare. Furthermore, pollutants associated with energy production are effectively inputs into a wider range of consumption goods.

ii. Inefficient relative taxation of multiple factors of production

This argument follows the above arguments of including intermediate factors of production and capital within the production function. It is concluded once again that if models that test for the existence of a double dividend are extended to consider more than one factor of production, a double dividend can occur if one factor is initially over-taxed relative to the other and the environmental tax improves the relative taxation of the factors.

The relatively high taxation of capital relative to labour in the US serves as an example of such a case. If the "tax shifting" from an environmental tax takes place in favour of capital rather than labour, the new environmental tax could cause relative taxation to improve. However, in the USA polluting industries are capital intensive and tax shifting is not enough to create a double dividend.

iii. Environmental feedbacks

Environmental improvements from an environmental tax could feed back on the functioning of labour and capital markets through possible effects on the improvement of the efficiency of these factors of production. An example would be an improvement in human capital through health improvements. Williams (2000) explored this productivity issue, but found that it is not large enough to result in a double dividend.

iv. Tax deductible expenditure

Most models that test for a double dividend neglect the fact that certain expenditures (such as mortgage interest) are deductible from income taxes. This distorts the choice between tax-favoured spending and ordinary spending, which means that the recycling of tax revenues through income tax cuts can yield an even larger revenue recycling effect, since cutting the income tax rate lowers the effective subsidy for tax-favoured spending.

It is clear from the economic literature that the attainment of the double dividend is only possible under certain "restrictive" conditions and that the introduction of an environmental tax could actually amplify distortions caused by existing taxes. A review of some empirical studies provides valuable insight into the various approaches that have been used to test for the double dividend hypothesis in various economies. Most of the studies performed on this topic are applied to the US and European economies and therefore distinction is made between these two economic regions, as

the features of these economies differ. While most of the studies in the US focus on the double dividend as a mechanism through which tax distortions can be addressed, the studies on the European economies focus on the possible gains to employment. The results of two policy studies on the US economy are analysed. This is followed by the examination of a study that analyses the Swedish economy, and a study that analyses the Spanish economy.

In each case the background of the study is described, followed by an explanation of the major defining characteristics of each model used in the analysis. Finally the results of each analysis are discussed. The model "characteristics" are included as it is evident that they can have a significant impact on the results of a study. The aim of this empirical review is to describe different approaches and results that have been used to analyse the double dividend hypothesis. Exhaustive detail is therefore avoided and can be obtained from the relevant literature.

4.6 THE DOUBLE DIVIDEND HYPOTHESIS: EMPIRICAL FINDINGS

4.6.1 Results from the US economy

The two studies that are discussed were part of an exercise of the Energy Modelling Forum at Stanford University (EMF) in the 1990s, in which a number of different economic models were used to assess the impact of carbon emission reductions on the US economy. The broad result from this exercise was a paper that compared a number of carbon-tax-with-revenue-recycling scenarios across four models. These models include two macro-econometric and two CGE models. The former are referred to as the DRI and LINK models, while the CGE models are referred to as the Jorgenson-Wilcoxen Model and the Goulder Model respectively. In the paper, Gross National Product (GNP), consumption and consumer utility were used as measures of welfare. The results from most of these simulations were that the revenue neutral environmental tax swap involved a reduction in welfare. The only exception was the results from the Jorgenson-Wilcoxen model that supported the notion of a strong double dividend. Closer examination of the difference between the Jorgenson-Wilcoxen result and that of the Goulder Model indicates that the elasticities of capital supply and capital demand are higher in the Jorgenson-Wilcoxen model. This difference resulted in a higher marginal excess burden of capital taxation in the Jorgenson-Wilcoxen model than that which prevailed in the Goulder model (Goulder, 1994, p24).

The Goulder and Wilcoxen models are both computable general equilibrium models, but they produce opposite results. A comparison of these models should provide valuable insight into conditions that will result in the attainment of a double dividend.

4.6.1.1 Effects of carbon taxes in an economy with prior tax distortion: an intertemporal general equilibrium analysis by Lawrence Goulder, 1995

i. Background to the analysis

In his research Goulder investigates how the use of carbon tax revenues and the nature of pre-existing taxes affect the cost of a carbon tax. Goulder addresses these issues by employing an intertemporal general equilibrium model of the US economy. This framework is useful for addressing interactions among energy (fossil fuel) industries as well as between energy industries and other sectors of the economy. The intertemporal focus shows how the effects of taxes change over time as households and firms alter saving and investment decisions.

ii. The model

The model that Goulder employs has three important features. Firstly, the model contains a detailed treatment of US taxes, which enables the model to account for pre-existing tax distortions, and to examine various options for using carbon tax revenues to finance reductions in distortionary taxes. Secondly, the model incorporates non-renewable resource supply dynamics and transitions from conventional to synthetic fuels. This facilitates the understanding of the effects of a carbon tax, since there are significant differences in the carbon content of conventional fuels and synfuels. Thirdly, the model incorporates capital adjustment dynamics. Because producer investment decisions take account of adjustment costs associated with the introduction of new capital, capital is rendered perfectly immobile.

iii. Production

Production within the model is represented by a nested production structure that accounts for potential substitutions between different forms of energy and other inputs. Each industry produces a distinct output, which is a function of capital, labour, energy, composite materials and current levels of investment. Capital and labour as well as energy and materials are aggregated within a CES technology. Capital adjustment costs are also included in the production function and they

affect output negatively, as installing new capital necessitates the use of inputs which could otherwise be used to produce output.

Firms in each industry are assumed to be price takers and to maximise value by choosing in each period the optimal levels of labour and intermediate inputs and investment, given personal tax rates on dividend income, capital gains and interest income.

The production structure of the oil and gas industry is different from the other industries in that it includes a resource stock effect that takes into account that these industries' stocks will deplete over time and that capital will eventually move to other industries.

All domestic prices in the model are endogenous except for domestic oil and gas prices, for which the world price is taken.

iv. Households

The decisions surrounding consumption, labour and savings are the result of the maximisation of the utility of an infinitely lived representative household. The household maximises an intertemporal utility function where consumption is a CES composite of goods, services and leisure. The household is subject to an intertemporal budget constraint. In each period, overall consumption of goods and services is allocated across the 17 specific consumption categories according to fixed expenditure shares.

v. Government sector

The government collects taxes, distributes transfers, and purchases goods and services, while government expenditure is exogenous and grows at a constant rate equal to the steady state growth of the economy.

vi. Foreign trade

Except for oil and trade, imported intermediate and consumer goods are imperfect substitutes for their domestic counterparts. Export demands are functions of the foreign price of US exports and the level of foreign income.

vii. Equilibrium

In equilibrium the aggregate demand for labour equals the aggregate supply, while the demand for each industry's output equals its supply. Aggregate demand by firms for loanable funds equals the aggregate supply of these funds by households. The government's tax revenues are equal to the difference between government spending and the government deficit.

viii. Results from the simulation

The first policy shock that Goulder tests within this framework is a carbon tax of 25, 50 and 100 1990 US dollars per ton of carbon where the tax applies on a consumption basis in the sense that it is applied to domestically produced and imported fossil fuels but exempts exported fuels. Revenue neutrality is assumed through reductions in either the marginal taxes on labour or capital at the personal level. This simulation is then compared with a situation in which revenues are returned in lump-sum to the economy.

Goulder finds that the costs of a carbon tax for GDP are significantly reduced when distortionary taxes are reduced relative to the case where revenue is returned to the economy in a lump-sum manner. The reason for this reduction is that, over time, the cuts in distortionary taxes allow for the improvement in intertemporal and inter-sectoral resource allocation. In terms of the welfare effects (as measured by the equivalent variation per dollar of revenue earned), the welfare loss is approximately 36 percent smaller when marginal taxes are reduced at personal level, 37 percent smaller when marginal taxes are reduced at payroll level and 42 percent when marginal taxes are reduced on all levels. However, cuts in distortionary taxes do not entirely eliminate welfare costs of the revenue neutral policy and it appears that, at the margin, a carbon tax generates larger gross distortionary costs than are produced by the major types of income taxes it might partially replace.

By performing different "base-case" scenarios where the type of taxation is changed from a pure carbon tax to that of a broad income tax, Goulder shows that the positive cost that arises from the carbon tax can be ascribed to the narrowness of a carbon tax base. Apart from the narrowness of the tax base, Goulder also shows that the existence of pre-existing distortions aggravates the costs

of an environmental tax because it raises the pure cost of the tax. These findings are also in the line with the theoretical findings of Bovenberg and De Mooij (1995).

4.6.1.2 Reducing U.S. carbon emissions: An econometric general equilibrium assessment by Dale Jorgenson and Peter Wilcoxen, 1994

i. Background to the analysis

The research performed by Jorgenson and Wilcoxen aims to establish the effects of a carbon emissions tax on the US economy. According to Jorgenson and Wilcoxen, the model that they employ has three features that set it apart from other studies that test for a possible double dividend. The first feature is that their model is a highly disaggregated model of the US economy that allows them to examine the effects of carbon taxes on narrow segments of the economy, such as particular industries or types of households. Secondly, they obtain all the parameters of their model by econometric estimation that allows their results to be consistent with historical trends. Thirdly, productivity growth is modelled at the industry level which allows it to be an endogenous function of relative prices.

These features of the model enabled the researchers to reach several important conclusions that can be briefly summarised as follows:

- In the USA the effect of a carbon tax will be very similar to the effects of a tax placed solely on the use of coal. Of all the fossil fuels, coal is the least expensive per unit of energy and produces the most carbon dioxide when burned. A tax on carbon emissions will raise the cost of coal-based energy more in percentage terms than the price of energy derived from oil or natural gas. This will result in a substantial decrease in the demand for coal.
- Because most of the coal that is consumed in the USA is used to generate electric power, electric utilities will convert some generating capacity to other fuels, although substitution possibilities are rather limited so that the tax will raise the cost of electricity significantly.
- Higher energy prices will lead to slow productivity growth, reduced capital formation and a reallocation of labour to lower-wage industries that will cause GDP to be lower than it would be in the absence of the tax.
- A carbon tax that is large enough to have a big effect on carbon emissions will raise tens to hundreds of billions of dollars annually. How this revenue is used will affect the overall burden of the tax.

ii. Production

Production is disaggregated into thirty-five industries. Each of the industries produces a primary product and may produce one or more secondary products. The behaviour of each industry is derived from a hierarchical tier-structured transcendental logarithmic cost function. At the highest level the cost of each industry's output is assumed to be a function of the prices of energy, materials, capital and labour. At the second level the price of energy is a function of the prices of coal, crude petroleum, refined petroleum, electricity and natural gas, while the price of materials is a function of all other intermediate goods. The parameters of each industry are estimated econometrically. An unusual feature of the model is that productivity growth is determined endogenously as a function of input prices.

iii. Consumption

Consumption behaviour is represented by assuming that households follow a three-stage optimisation process. At the first stage each household allocates full wealth (the sum of financial wealth plus the imputed value of leisure time) across different periods of time. That is, the household maximises an additive intertemporal utility function subject to a budget constraint. At the second stage households allocate full consumption to goods and leisure in order to maximise an indirect utility function. The demand for leisure implicitly determines labour supply, while the difference between current income and consumption of goods implicitly determines savings. The third stage of the household optimisation problem is the allocation of total expenditure among capital services, labour services and thirty-five commodities. At this stage distinction is made between 1344 household types according to demographic characteristics.

iv. Investment and capital formation

It is assumed that there is a single stock of capital in the economy of which the supply is fixed in the short run. However, it is also assumed that capital is malleable and can be reallocated among industries and also between industries and final demand, at zero cost. The price of a unit of capital is therefore equal in every industry and there will be a single, economy-wide rate of return on capital.

v. Government

Government behaviour in the model is specified by computing total government spending on goods and services. Exogenous tax rates are applied to taxable transactions in the economy, to which capital income and non-tax receipts are added to obtain total government revenue. It is further assumed that the government deficit can be specified exogenously. This is then added to total revenue to obtain total government spending. Government spending is allocated among commodity groups according to fixed shares constructed from historical data.

vi. Foreign sector

It is assumed that imports are imperfect substitutes for similar domestic commodities and the mix of goods purchased by households and firms reflects substitution between domestic and imported products. Exports are determined by a set of export demand functions that depend on the foreign income and foreign prices of US exports.

vii. Results from the simulation

In calculating the amount of carbon dioxide emissions in the economy, it is assumed that carbon dioxide is produced in fixed proportions to fossil fuel use. The carbon content of each fuel used is then calculated by multiplying the amount of fuel used by the amount of carbon emitted per billion of BTU produced from each fuel. A carbon tax is introduced on both the domestic and imported sources of carbon emissions. The level is chosen to be exactly enough to hold US carbon dioxide emissions at their 1990 value of 1576 million tonnes. Although Jorgenson and Wilcoxen run simulations where the tax revenue is returned in a lump-sum fashion to households, the result of interest is where the tax revenues are used to reduce a distortionary tax. That is, lowering either taxes on labour or capital. The result of these simulations shows that when the revenue is returned by lowering the tax on labour, the loss of gross national product (GNP) is only 0.69 percent, which is half the decrease when the revenue is returned lump-sum. However, when the revenue is used to lower taxes on capital, the level of GNP actually increases. Because the marginal excess burden of

taxation in the US is higher on capital than on labour, the revenue neutral tax allows some correction for this inefficiency.

4.6.2 Results from the European economies

As mentioned in the introduction, the studies that have been performed on the European economies differ in their approach to that of the studies that were performed on the USA economy, in that it tries to address the problem of unemployment. To this regard the emphasis is placed on the use of the carbon tax revenue to lower the cost of labour. The success of these policies is therefore dependent on the reaction of the labour market to these cost lowering incentives. Given this approach, the European experience seems to be more in line with the South African situation.

4.6.2.1 General equilibrium effects of increasing carbon taxes in Sweden by Glen Harison and Bengt Kristrom, 1997

i. Background to the analysis

Sweden signed the Rio declaration on the reduction of greenhouse gas emissions, which states that the current environmental goal is to stabilise CO_2 emissions to levels that pertained in 1990. In 1995 the Swedish government launched a commission to provide an analysis of a tax system intended to have a stronger environmental profile. The commission was asked to evaluate prevailing environmental taxes and to scrutinize the potential for a "double dividend" that could arise from new carbon taxes. The goal was to look at the impact of new taxes on the labour market, the government budget, competitiveness, dynamic impacts, distributional impacts and environmental aspects. Because Sweden is a small open economy it is also important to look at the impact of a revenue neutral tax-swap on international competitiveness.

ii. Production

The model used in this analysis identifies 87 sectors of production. Each sector in the model produces output by using inputs and a value added composite of the primary factors. These are combined through a CES technology with a low elasticity of substitution across all sectors. The value added is a CES composite of the labour composite and capital, while the labour is a CES combination of the different labour skill types. The model also allows for the specification of sector

specific capital types in any set of sectors. This allows for the identification of sectors that employ a significant amount of primary factor that can be interpreted as specific to that sector. This could be interpreted as referring to a "short-run" in which capital is applied to sectors in a manner that does not permit it to be readily moved to other sectors. According to Harison and Kristrom (1997) it is intuitively clear that as the relative demand of output for a specific industry falls, *ceteris paribus* all input prices, the factor that is specific to this industry cannot escape to other industries. It must therefore experience a larger drop in real return than when it is inter-sectorally mobile. This relatively sharp decline in factor input cost results in a larger drop in the supply price in that specific industry than when the factor is assumed mobile.

iii. Households

Distinction is made between 30 households. The households are differentiated by family status and income. Final demand by households arises from a nested constant elasticity of substitution utility function. This allows consumer decision making to occur in the form of multi-stage budgeting. At the top-level goods from different sectors compete subject to the budget constraint of the consumer, and all income elasticities are equal to one. In the second stage the consumer decides how much to spend on domestic or imported goods in each sector, subject to the income allocated to spending on that sector in the first stage. Each allocation decision is modelled as a CES technology.

iv. Government expenditures and investment demand

Government expenditures and investment demand are exogenous and tax revenues and tariff revenues provide funding for government expenditures. The government also derives revenues from indirect taxes. Any lost revenues are recovered by increasing taxes on labour that are collected at the enterprise levels. Similarly, labour taxes are reduced for any increase in revenue.

v. Trade

Because the Swedish economy is a small open economy, trade is modelled as occurring at fixed world prices, although Swedish importers may substitute between alternative import sources and domestic production and the import composite. Similar assumptions apply on the export side, where Swedish producers have a constant elasticity of transformation between the sale to domestic markets and a composite foreign market, and sales of the composite to any of several foreign trading partners.

Because the specification of energy and carbon taxes is central to the model, taxes are modelled as falling on trade in intermediate inputs. This allows flexibility to calibrate the model to capture distortionary effects of existing taxes at the correct margin.

vi. Results from the simulation

Estimates of carbon emissions in each sector were derived on the basis of information on physical usage of primary energy inputs. This data can be used to infer the amount of CO_2 emissions generated by each sector, since emissions are a reliable multiple of the physical amount of energy used.

The core simulation based on this model is one of a 100 percent increase in existing carbon taxes in Sweden. By default labour taxes are lowered to ensure equal government revenue after the carbon tax policy. The results indicate that all household groups lose from the doubling of the existing carbon tax, with richer households bearing a higher cost, which reflects the greater carbon intensity of their expenditure patterns. On the other hand, the policy shock results in a reduction of 52 Kilotons of CO_2 in the economy, even though some sectors experience an expansion in CO_2 emissions and others experience a contraction. This is what one would expect in a general equilibrium analysis when relative prices change.

4.6.2.2 Implementing a double dividend: recycling ecotaxes towards lower labour taxes by Antonio Manresa and Ferran Sancho, 2002

i. Background to the analysis

The authors attempt to provide an answer to the possibility of attaining a double dividend by making use of a large size numerical model where general economic interdependence is fully taken into account. They feel that most contributions to the testing of the double dividend hypothesis are essentially analytical and deal with small size economic models. The model that is implemented in this study therefore uses the rich data set contained within a Social Accounting Matrix of Spain. The authors find that, under certain plausible conditions on the structure of the economy, it is indeed possible to obtain a double dividend. A budget neutral tax reform can yield a better environment and, at the same time, improve the employment levels while it also improves the efficiency of the Spanish tax system. The policy shock to the economy is one where an

environmental tax (*ad-valorem* tax on all energy goods) is introduced, while payroll taxes are lowered across all production sectors under a budget neutral restriction.

The authors claim that the reason for the attainment of a double dividend rests in the inefficiency of taxation over primary factors (labour and capital) in the Spanish fiscal system, where there is a relatively high tax on labour use compared to taxes levied on capital which are inelastically applied in the model.

ii. Production

Production takes place under constant returns to scale where maximum profits are zero and a firm's behaviour is reduced to cost minimisation. The production side of the model used in this study distinguishes between 22 industries of which 10 correspond to energy production activities. Domestic output is obtained by using a fixed coefficient technology that combines intermediate inputs and value added. Value added is a composite primary factor that is generated by combining capital and labour services with a Cobb-Douglas technology.

iii. Households

Households maximise a utility function that combines different types of consumption and savings in a Cobb-Douglas technology. The budget constraint is a function of the direct income tax rate, consumer prices, the price of capital and the price of labour respectively. Consumption demand depends upon goods' prices and disposable income, which in turn depends on factor prices and the unemployment rate.

iv. Government

The government collects tax income that is spent to provide public consumption, public investment and government transfers to the private sector. The model distinguishes between the following tax categories: aggregate income tax, production indirect tax, value-added tax, payroll tax, tariffs and an environmental tax.

By adding all income tax sources, total tax collection is obtained, which depends on the applicable tax base.

v. Trade

The foreign sector plays a residual but nonetheless important role in the model. Distinction is made between two foreign sub-sectors; the European Union and the rest of the world. Imports are demanded by domestic industries and are used along with domestic output to provide the total supply of goods.

vi. Equilibrium

The model's equilibrium is essentially Walrasian, but also includes a macro rule that affects the labour market by including a relationship that reflects the sensitivity of the unemployment rate to the wage rate. In equilibrium, markets for goods clear, market for factors of production clear, total tax collections are equal to total tax payments and total investment is equal to total savings.

vii. Results from the simulation

In evaluating the results from the policy shock, Manresa and Sancho state that CO_2 emissions are a natural by-product of economic activities and that there is a direct link between the level of economic activity and the level of emissions. The evaluation of CO_2 emissions must therefore take into account, on the production and final demand sides, only those emissions that effectively take place on national territory and should therefore only count emissions generated in domestic production activities and in domestic final demand, ruling out any exported emissions.

The policy simulation performed encompasses the adoption of an environmental tax on the use of energy products and maintains the level of government tax collections by way of a compensating decrease in social security contributions by employers. The result of the policy shock is that the reduction in the social security contributions of the employer yields a positive impetus to the Spanish economy, as the distinct reduction in the relative cost of using labour proves to be a sufficient stimulant to substitute capital for labour and reduce unemployment, along with a 2.8 percent reduction in CO_2 emissions, which corresponds to the strongest form of the double dividend hypothesis.

4.7 CONCLUSION

The discussions on the existence of the double dividend illustrate that a double dividend could arise if three conditions hold:

i. The initial tax system is inefficient along some non-environmental dimension.
ii. The revenue-neutral environmental tax reduces this inefficiency.
iii. The efficiency improvement along this dimension more than compensates for the environmental tax's inherent efficiency disadvantage that is brought about by the narrow base of environmental taxes.

The discussion on the double dividend hypothesis also indicates that the existence of the strong form of the double dividend hypothesis in an economy will allow policy makers to introduce an environmental tax without having to prove the benefits of a cleaner environment to society.

Although partial equilibrium analysis indicates that the benefit of such an environmental tax will be positive, subsequent general equilibrium analysis, on balance, indicates the opposite. The reason for the latter result is that, apart from a few cases, environmental taxes usually increase the distortions caused by existing distortionary taxes. This increase in inefficiency is usually bigger than the decrease obtained by reducing the distortionary tax with revenue obtained from the environmental tax. However, there seems to be circumstances in which an environmental tax could indeed be used to reduce distortionary taxes and obtain a positive welfare benefit to society.

The brief analysis of a few empirical findings on the double dividend hypothesis confirms that the attainment of a double dividend in an economy is ambiguous, and that much depends on the structure of the economy and the model used to analyse such a policy. The studies that have been performed on the US economy indicate that a double dividend can be obtained if the marginal excess burden from taxation is relatively high on one factor of production. Because the USA does not have a significant unemployment problem, these studies seem to focus on an increase in the use and efficiency of capital as a factor of production.

In contrast to the US findings, the studies performed on European economies focus more on unemployment and indicate that a double dividend could be obtained if the supply of labour does not react negatively to lower real wages. A relatively low wage elasticity of supply could result in an increase in unemployment because the increase in the demand for labour will result in an increase in real wages (not necessarily in an increase in employment). This will ultimately result in increased inflation and a decrease in economy-wide welfare. The opposite, however, is also true, as a high wage elasticity of supply would result in a relatively small decrease of labour supply that will be offset by an increase in labour demand.

Because of South Africa's problem of high unemployment, the results from the European studies seem more applicable to the South African situation. The review of the South African labour market in Chapter 3 indicated that the South African unemployment problem is not a labour supply problem, but rather a labour demand problem, and that it is possible that a double dividend could be obtained.