4. Method 1 : MODEL STRUCTURE

In proposing a welfare measure, we in no way deny the importance of conventional national income accounts or of the output measures based upon them.
(Nordhaus and Tobin 1972)

4.1 Introduction

In view of the fact that international consensus has not yet been reached on how to incorporate environmental costs and benefits in the national accounts, it seems premature to radically change a well-established system of economic accounts. Thus, models developed for this study are still based on the Neo-classical framework of income accounts. A successful integration of the environment and leisure in the standard national (economic) accounts serves the purpose of bringing environmental considerations into the decision-making process. Resource accounting and leisure valuation are crucial to the assessment of the environmental consequences of economic activities and the importance of leisure to a society's welfare.

Recent studies on national accounting system point to the need of including environmental resources and leisure in the national accounts. The theoretical models of this research are extensions of McCallum (1989), which integrates the government sector to the real business cycle (RBC) model. The first model represents the unadjusted Gross National Expenditure (GNE). This model incorporates the disutility associated with production and consumption in its production function specifications. The second model, which also uses the RBC model, integrates government defensive expenditure in the model specifications. The third model expands the second model by imputing for the value of leisure.

The discussion of this chapter observes the following order. Section 4.2 describes the first model. This model is referred to as the Unadjusted Gross National Expenditure

(Unadjusted GNE) model. The sum of private and government final consumption expenditure, and gross fixed capital expenditure, is often referred to as domestic final demand. In the Australian National Accounts, the sum of domestic final demand and increase in stocks is shown as Gross National Expenditure (GNE). Section 4.3 depicts the second model known as the Adjusted Gross National Expenditure 1 (Adjusted GNE (1)). A model known as Adjusted Gross National Expenditure 2 (Adjusted GNE (2)) that incorporates leisure value in the GNE computations is introduced in Section 4.4. A summary is presented in Section 4.5

4.2 Model 1: Unadjusted GNE

The social costs of environmental destruction and the accelerated exploitation of rural resources have clearly become a centre of public attention today. It has become increasingly obvious that the ways in which people use cars, burn coal for electricity, drop their waste into landfill sites and their sewerage into rivers and the sea cannot continue indefinitely. It seems that the main origin of social and ecological cost is a specific pattern of production and consumption in a society in which economic decisions are made under market conditions (Leipert 1989). In a market economy every firm aims to maximise profits or to minimise costs. This means that a firm will always try to systematically make greater use of cost free factors of production, such as the services of the natural environment, than if it were obligated to pay for those inputs. A firm will, whenever possible, try to replace cost-sensitive production factors such as labour and capital with cost-free environmental functions. This structure of economic incentives has led to a structure of production, technology, consumption, transport and settlement that severely strains the environment. At the end of the 1960s, it became increasingly visible that the process of growth was exceeding the threshold of the environment's carrying capacity. At that point, rapidly mounting damage became noticeable in many areas. With this in mind, a model that incorporates environmental deterioration in the computations of the national accounts is proposed.

4.2.1 Basic equations for Unadjusted GNE

Following McCallum (1989), it is assumed that an economy is composed of a large number of similar, infinitely lived households, each of which acts in time t to maximise

$$E_t \sum_{j=0}^{\infty} \beta^j u\left(C_{t+j}^n, L_{t+j}^n\right) \tag{4.1}$$

Here, C_{t+j}^n and L_{t+j}^n denote the household's effective consumption and leisure during period t, while β is a discount factor ($0 < \beta < 1$) that reflects a preference for current over future consumption and leisure. Application of the operator $E_t(.)$ yields the mathematical expectation, contingent upon complete information up to period t, of the indicated argument. In other words, the household will do the best they can with the information they have. The utility function $u(.)$ is assumed to be increasing in both arguments, strictly concave, differentiable and "well-behaved" (King *et al* 1988).

In the above equation, C_t^n and L_t^n denote the household's effective consumption and leisure during period t. Departing from McCallum's model, effective consumption is defined as

$$C_t^n = C_t + \theta_1 G_{1t} \tag{4.2}$$

where C_t is the private consumption of goods and services and G_{1t} is a component of government expenditure on goods and services that substitute partially for private consumption, with θ_1 representing the degree of this 'substitutability'. Here it is assumed that effective consumption is determined not only by private consumption expenditure but also by government consumption expenditure. Some of the goods and services consumed by households are partly or totally provided by the government. Examples include health services, performing arts services, national parks and wildlife and many others. As more of these goods and services are provided by the government, the level of effective consumption rises. The parameter θ_1 measures the degree of substitutability between private consumption expenditure on goods and services and government consumption expenditure on goods and services. A value of 1 for θ_1 means that households value the goods and services provided by the government as comparable with those services they can get from the private sector. However, here it is assumed that the government does not spend on protecting the environment. Thus, effective consumption C_t^n is defined as the private consumption expenditure of the households on goods and services only.

Likewise, the production function is modified to include the environmental deterioration that emanates from increased level of production. It is assumed that each household's output can be represented by a production function of the form

$$Y_t^n = \varepsilon_t f(n_t^d, k_t^d) \tag{4.3}$$

where $0 < \varepsilon_t < 1$ *and represents environmental, productivity disturbances*

The output Y_t^n is produced from inputs of labor (n_t^d) and capital (k_t^d). In addition, the production function in equation (4.3) follows Kydland and Prescott's (1982) assumption that a single good is produced by labour and capital. The variable Y_t^n represents the output of the economy without government expenditure on the environment and the parameter ε_t is the unobserved, environmental, productivity disturbances. The parameter $(1-\varepsilon_t)$ measures the degree of environmental degradation. The function *f(.)* has the usual monotonicity and curvature properties and it is homogeneous of degree one, with positive but diminishing marginal product.

As emphasised in the previous chapter, people experience disutilities from the disturbance of the natural environment stemming from the production process. In nearly all sectors, the process of production affects the functionality of the environment. Studies on environmental pollution control (Stephens 1976, Bensoussan *et al* 1978) offer insights into the possible impact of production on the environment.

Stephens (1976) found that "a unit increase in forgone production (with given amounts of capital and labour) reduces the net pollution flow by an amount equal to the reciprocal of the marginal product of pollution". Also, increases in production in order to enrich consumption have a direct effect on the amount and composition of household waste (Uusilato 1983). In his study for the Netherlands, Van Ophen (1992) reported that during the period of economic recession of 1980-1982 the amount of waste fell. Likewise, several examples can be cited in agricultural production. Chemical residues in the soil and soil erosion are probable outcomes of agricultural production activity. Similarly, as a result of power generation activity, harmful emissions of SO_x, NO_x and CO_2 may be generated.

Since evidence supports the contention that economic acts of production do not only benefit man but simultaneously create waste which is potentially harmful to the environment, the conventional production function has to be extended to include environmental deterioration. Accordingly, variable ε_t is introduced in equation (4.3) as the environmental productivity disturbances coefficient associated with the production process. The parameter ε_t has a value greater than zero but less than one and captures the decrease in utility individuals associate with environmental exploitation through increases in production. When ε_t is almost equal to one (1), which implies that (1-ε_t) is nearly equal to zero, it means that production activities have minimal harmful effects on the environment. The result can be interpreted to indicate that the level of environmental degradation is close to zero.

As in McCallum's (1989) model, in this simple Neo-classical framework the commodity can either be consumed or invested. Thus the capital stock equation is written as

$$k_{t+1}^{n} = e_t[(1-\delta)k_t + I_t^n] \tag{4.4}$$

where $0 < e_t < 1$ *and represents disturbances associated with capital stock* where δ is the constant rate of depreciation of capital and I_t^n is the effective level of investment, which is given by

$$I_t^n = I_t + \theta_2 G_{2t} \tag{4.5}$$

where G_{2t} is government investment expenditure, which are assumed to substitute for private investment. Here it is assumed that there is a certain amount of savings available for private and public investment in a given year. Thus, if money available for government investment increases, the amount of money available for private investment decreases. The parameter θ_2 is designed to capture the degree of substitutability between private investment and government investment. The absolute value of θ_2 ranges from 0 to 1. When θ_2 equals 1 households perceive government investment expenditure as a perfect substitute for private investment.

But unlike McCallum's model, the parameter e_t is added to represent the disutility associated with capital stock. The usual capital stock function has to be extended to capture the environmental problems associated with production. From the point of view of physical relationships, production is nothing but a transformation process of materials for which the physical law of the 'conservation of mass' must be valid. The total mass of inputs (raw materials, energy, etc.) must be equal to the total mass of outputs, in other words, equal to useful 'economic' goods for consumption, investment and waste. Equation (4.4) reflects the fact that the economy's capital stock depreciates and whatever cannot be recycled becomes waste mostly in the form of solid waste. Evidence show that the pursuit of high rates of industrial growth has raised the level of environmental degradation by increasing waste emissions (water and air pollution, and industrial waste) to levels which exceed the environment's assimilative capacity. Recognising the presence of wastes in the production process, e_t, indicates that there is some disutility associated with capital stock because of potentially harmful effects.

In addition, it is assumed that households own all factors of production, renting them to profit maximising firms each period at wages and capital rentals w_t and q_t. With this additional assumption, the household budget constraint becomes

$$C_t + I_t + w_t n_t^d + q_t k_t^d + T_t = \varepsilon_t f(n_t^d k_t^d) + w_t n_t + q_t k_t \tag{4.6}$$

which simply means that sources of funds are equal to the use of funds. From equation (4.6), the sources of funds are identified as the output produced as well as the labour (n_t) and capital (k_t) services sold to the competitive market. The uses of funds include consumption, investment and the hiring of capital (k_t^d) and labour (n_t^d) services by the household.

Now let households be endowed with $\bar{n}$ units of time each period. Further, let the current period leisure be equal to L_t^n and the labour sold to firms as n_t. The rule which applies to leisure and work follows

$$\bar{n} = L_t^n + n_t$$

which when normalised to 1 becomes

$$1 = L_t^* + n_t^* \tag{4.7}$$

where

$$L_t^* = {L_t^n}/{\bar{n}}$$

$$n_t^* = {n_t}/{\bar{n}}$$

Equation (4.7) simply means that the individual's total time allocated to work and leisure must not exceed the time endowment available in each period.

As a further modification of McCallum's model, government purchases denoted by G_t on per household basis, are incorporated in the model structure. The government budget constraint is specified as

$$G_t = G_{1t} + G_{2t} = T_t \tag{4.8}$$

As defined in the previous equations, G_{1t} and G_{2t} are government expenditure on goods and services and government investment. Here it is assumed that the government does not spend anything on protecting the environment and correcting environmental damage. Further, it is assumed that lump-sum taxation and a balanced budget prevail in each period.

By combining equations (4.2) to (4.8), the budget constraint faced by a typical household in period t is

$$\begin{aligned} &C_t^n - \theta_1 G_{1t} + \tfrac{1}{e_t} k_{t+1} - (1-\delta)k - \theta_2 G_{2t} + G_{1t} + G_{2t} = \\ &\varepsilon_t f(n_t^d, k_t^d) - w_t (n_t^d - n_t) - q_t (k_t^d - k_t) \end{aligned} \tag{4.9}$$

The variable k_t represents capital stock without government defensive expenditure, and by definition is equal to the capital hired by the household, thus $k_t = k_t^d$. At time t, households act to maximise equation (4.1) subject to a sequence of constraints of the form given by equation (4.9). From these two equations, a lagrangian equation can be specified.

4.2.2 Model solution for unadjusted GNE

The Lagrangian equation is derived by combining the objective function given by equation (4.1) and the resource constraints specified by equation (4.9). The resulting equation is of the form

$$\mathcal{L} = E_t \sum_{j=0}^{\infty} \beta^j \{u(C^n_{t+j}, L^n_{t+j}) - \lambda_{t+j}[C^n_{t+j} + \tfrac{1}{e_{t+j}} k_{t+j+1} - (1-\delta)k_{t+j} + (1-\theta_1)C_{1,t+j} + (1-\theta_2)G_{2,t+j} - \varepsilon_{t+j} f(n^d_{t+j}, k^d_{t+j}) + w_{t+j}(n^d_{t+j} - n_{t+j}) + q_{t+j}(k^d_{t+j} - k_{t+j})]\} \qquad (4.10)$$

The first order conditions for maximising equation (4.1) subject to equation (4.9) are as follows:

w.r.t C^n_{t+j} $\quad E_t u_1(C^n_{t+j}, 1-n_{t+j}) = E_t \lambda_{t+j} = 0$ (4.11a)

w.r.t n_{t+j} $\quad -E_t u_2(C^n_{t+j}, 1-n_{t+j}) + E_t(\lambda_{t+j} w_{t+j}) = 0$ (4.11b)

w.r.t. n^d_{t+j} $\quad E_t\left[\varepsilon_{t+j} f_1(n^d_{t+j}, k^d_{t+j})\right] - E_t w_{t+j} = 0$ (4.11c)

w.r.t. k^d_{t+j} $\quad E_t\left[\varepsilon_{t+j} f_2(n^d_{t+j}, k^d_{t+j})\right] - E_t q_{t+j} = 0$ (4.11d)

w.r.t. I^n_{t+j} $\quad -E_t(\lambda_{t+j}, \frac{1}{e_{t+j}}) + E_t \beta \lambda_{t+j+1}[\varepsilon_{t+j+1} f_2(n^d_{t+j}, k^d_{t+j}) - (1-\delta)] = 0$ (4.11e)

The notation λ_{t+j} represents the Lagrangian multiplier associated with the period $t+j$ budget constraint. It can further be interpreted as the discounted utility that can be obtained from the extra unit of a good in the period $t+j$.

Together, conditions (4.11a) to (4.11e) are necessary and sufficient for an optimum. An interpretation of the first order conditions (4.11a) to (4.11e) is straightforward. Equations (4.11a) and (4.11b) imply that the marginal rate of substitution between leisure and consumption equals the real wage. In competitive markets for labour and capital, the marginal products of these inputs should equal the real wage (4.11c) and the real rental rate for capital services (4.11d). Equation (4.11e) shows the optimal conditions for the choice of investment. The same equations can be interpreted to mean that at the optimum, the loss of utility by foregoing a unit of the good today (including storing and consuming the good in the future) must be equal to the discounted utility gained tomorrow.

Other than the conditions specified above, there is also a transversality condition, concerning the long-term accumulation of capital. This relationship can be written as

$$\lim_{j\to\infty} E_t \beta^{j-1} \lambda_{t+j} k_{t+j+1} = 0 \tag{4.11f}$$

Condition (4.11f) rules out the possibility that the household would forever accumulate capital at an excessive rate, which is not stipulated by any of the other conditions. Together, equations (4.10) and (4.11a to 4.11f) are necessary and sufficient for an optimum. They define the typical household's choice of $C^n_{t+j}, I^n_{t+j}, n_{t+j}, n^d_{t+j}$ and k^d_{t+j} in response to the current values of w_{t+j} and q_{t+j}, its expectations about the future, and its accumulated stock of capital, k_{t+j}..

Furthermore, it is assumed that the market clearing conditions for labour and capital services hold as $\sum n^d_t = \sum n_t$ for labour and $\sum k^d_t = \sum k_t$ for capital. Assuming that households are alike, the above condition would make aggregation possible. Since households experience the same value for ε_t (environmental, productivity disturbances) it is implied that $n_t = n^d_t$ and $k_t = k^d_t$.

Using the Neo-classical framework of income accounts, the relationship between income, consumption, investment and government expenditure can be written as

$$\begin{aligned} Y^n_t &= C_t + I_t + G_t \\ &= C^n_t + I^n_t + (1-\theta_1)G_{1t} + (1-\theta_2)G_{2t} = \varepsilon_t f(n_t, k_t) \end{aligned} \tag{4.12}$$

The above equation implies that at equilibrium, income is equal to aggregate expenditure. Additionally, it is assumed that expectations are rational. This assumption implies that the mathematical conditions (4.9) and (4.11) are based on a probability distribution that coincides with the economy's structure (as represented by the model). Thus, the competitive market equilibrium conditions in this economy can be characterised by the following set of equalities :

$$u_1(C_t^n, 1-n_t) - \lambda_t = 0 \tag{4.13a}$$

from equation (4.11a)

$$u_2(C_t^n, 1-n_t) - \lambda_t \varepsilon_t f'(n_t, k_t) = 0 \tag{4.13b}$$

from equations (4.11b) and (4.11c)

$$-\lambda_{tt} + \beta\lambda_{t+j+1}\{\varepsilon_{t+1} f_2(n_{t+1}, k_t)\} = 0 \tag{4.13c}$$

$$\therefore \beta\lambda_{t+1}\varepsilon_{t+1} f_2(n_t, k_t) - \beta\lambda_{t+1}(1-\delta) = \lambda \frac{1}{e_t}$$

from equation (4.11e)

$$C_t^n + I_t^n = \varepsilon_t f(n_t, k_t) - [(1-\theta\ )G_{1t} + (1-\theta_2)G_{2t}] \tag{4.13d}$$

from equation (4.9)

To derive the optimal solution and to illustrate the model, specific production and utility functions are used. Here it is assumed that the production function and the utility functions are of the Cobb-Douglas and linear in log form respectively. Taking into account these assumptions, the following equations are derived.

$$\begin{aligned} Y_t^n &= \varepsilon_t f(n_t, k_t) \\ &= \varepsilon_t n_t^{\alpha} k_t^{1-\alpha} \end{aligned} \tag{4.14}$$

$$u(C_t^n, 1-n_t) = \phi_1 \ln C_t^n + \phi_2 \ln(1-n_t) \tag{4.15}$$

In addition, it is assumed that capital requires a complete depreciation rate within a single period. The coefficients ϕ_1 and ϕ_2 represent the elasticity of consumption and leisure respectively.

Using the functional forms imposed by equations (4.14) and (4.15), the system of equations given by equations (4.13) becomes

$$\frac{\phi_1}{C_t^n} - \lambda_t = 0 \tag{4.16a}$$

from equation (4.13a)

$$\frac{\phi_2}{1-n_t} = \lambda_t\, \varepsilon_t\, \alpha\, n_t^{\alpha-1} k_t^{1-\alpha} \tag{4.16b}$$

from equation (4.13b)

$$\lambda_t \frac{1}{\varepsilon_t} = \beta(1-\alpha)\lambda_{t+1}\varepsilon_{t+1} n_{t+1}^{\alpha} k_{t+1}^{-\alpha} \tag{4.16c}$$

from equation (4.13c)

$$C_t^n + I_t^n = \varepsilon_t (n_t^{\alpha} k_t^{1-\alpha}) - \left[(1-\theta_1)G_{1t} + (1-\theta_2)G_{2t}\right] \tag{4.16d}$$

from equation (4.13d)

Now, it is assumed that C_t^n is proportional to $X_t Y_t^n$. Also, let $X_t = \frac{Y_t^n - \left[(1-\theta_1)G_{1t} + (1-\theta_2)G_{2t}\right]}{Y_t^n}$. Then, C_t^n and I_t^n can be expressed as

$$C_t^n = \delta X_t Y_t^n \tag{4.17}$$

$$I_t^n = (1-\delta) X_t Y_t^n \tag{4.18}$$

By combining equations (4.16a) and (4.16b), then

$$\frac{\phi_2}{1-n_t} = \frac{\phi_1}{C_t^n}\left[\varepsilon_t \alpha\, n_t^{\alpha-1} k_t^{1-\alpha}\right] \tag{4.19}$$

and substituting $C_t^n = \delta X_t Y_t^n$, it becomes

$$\frac{\phi_2}{1-n_t} = \frac{\phi_1}{\delta X_t Y_t^n}\left[\varepsilon_t \alpha\, n_t^{\alpha-1} k_t^{1-\alpha}\right]$$

Using the relation $g(G_{31t}, G_{32t})n_t^{\alpha-1}k^{1-\alpha} = \frac{Y_t^n}{n_t}$, we rewrite equation (4.19) as

$$\frac{1-n_t}{n_t} = \frac{\phi_2 \delta X_t}{\alpha\phi_1} = \frac{\phi_2\delta}{\alpha\phi_1}\left[\frac{Y_t^n - (1-\theta_1)G_{1t} - (1-\theta_2)G_{2t}}{Y_t^n}\right]$$

Therefore, by substituting the X_t expression in the equation and by defining $G_{1t} / Y_t^n = g_{1t}^n$ and $G_{2t} / Y_t^n = g_{2t}^n$, he equation becomes

$$\frac{Leisure}{Labour} = \frac{1-n_t}{n_t} = x_t = \frac{\phi_2\delta}{\alpha\phi_1} - \frac{\phi_2\delta(1-\theta_1)}{\alpha\phi_1} g_{1t}^n - \frac{\phi_2\delta(1-\theta_2)}{\alpha\phi_1} g_{2t}^n \tag{4.20}$$
$$= \beta_0 + \beta_1 g_{1t}^n + \beta_2 g_{2t}^n$$

where

$$\beta_0 = \text{constant term} = \frac{\phi_2\delta}{\alpha\phi_1}$$

$$\beta_1 = -\frac{\phi_2\delta(1-\theta_1)}{\alpha\phi_1}$$

$$\beta_2 = -\frac{\phi_2\delta(1-\theta_2)}{\alpha\phi_1}$$

The reduced form equation for the eisure-labour ratio (x_t) shows that it is a function of government expenditures on goods and services (g_{it}) and government investment expenditure (g_{2t}) only. Since the reduced form equation has been derived using the equilibrium analysis, it is assumed that the influences other than those of g_{it} and is g_{2t} captured by β_0. The following definitions are used, $\frac{C_t^n}{Y_t^n} = c_t^n$ and $\frac{I_t^n}{Y_t^n} = i_t^n$. Following the derivation in Append x B, the consumption function becomes

$$C_t^n = \delta X_t Y_t^n$$
$$c_t^n = \delta X_t$$
$$c_t^n = \delta\left[\frac{Y_t^n - (1-\theta_1)G_{1t} + (1-\theta_2)G_{2t}}{Y_t^n}\right]$$
$$\begin{aligned} c_t^n &= \delta - \delta(1-\theta_1)g_{1t}^n - \delta(1-\theta_2)g_{2t}^n \\ &= \beta_0 + \beta_1 g_{1t}^n + \beta_2 g_{2t}^n \end{aligned} \tag{4.21}$$

where

$\beta_0 =$ constant term $= \delta = 1 - \beta + \alpha\beta$,

$\beta_1 = \delta(1-\theta_1) = (1-\beta+\alpha\beta)(1-\theta_1)$ and

$\beta_2 = \delta(1-\theta_2) = (1-\beta+\alpha\beta)(1-\theta_2)$

while the investment function is

$$I_t^n = (1-\delta)X_t Y_t^n$$
$$i_t^n = (1-\delta)X_t$$
$$i_t^n = (1-\delta)\left[\frac{Y_t^n - (1-\theta_1)G_{1t} - (1-\theta_2)G_{2t}}{Y_t^n}\right]$$
$$\begin{aligned} i_t^n &= (1-\delta) - (1-\delta-\theta_1+\delta\theta_1)g_{1t}^n - (1-\delta-\theta_2+\delta\theta_2)g_{2t}^n \\ &= \beta_0 + \beta_1 g_{1t}^n + \beta_2 g_{2t}^n \end{aligned} \tag{4.22}$$

where

$\beta_0 =$ constant term $= (1-\delta) = (1-\alpha)\beta$

$\beta_1 = (1-\delta-\theta_1+\delta\theta_1) = (\beta - \alpha\beta)(1-\theta_1)$

$\beta_2 = (1-\delta-\theta_2+\delta\theta_2) = (\beta - \alpha\beta)(1-\theta_2)$

Again, equations (4.21) and (4.22) mean that consumption and investment are a function of government expenditure on goods and services as well as government expenditure on investment. The derivation of the values of δ and $(1-\delta)$ are also detailed in **Appendix A**.

4.3 Model 2: Adjusted GNE (1)

Economic development studies during the early fifties and sixties failed to account for the effect of exponential growth of output, consumption, raw materials, energy, and industrial waste (flow variables) or nature and people (stocks). They overlooked the fact that it was the continued maintenance of these stocks that the flow themselves depended on. Society today must divert increasing proportions of economic resources to address the issue of environmental damage and to restore environmental functions that were used at little or no cost in the bygone epoch without notable environmental damage. As general concern about environmental quality has been increasing, a new research area has emerged namely, the impact of defensive expenditure on levels of consumption and welfare. One of the central tenets of modern society is the expansion of the consumption of goods. The central tenets of 'achievement' and 'consumption' have guided a social system, which through economic growth, has succeeded in improving the material wealth of people. However, the cost of growth fell on the environment, which has been exploited. Much thought has been given to the negative and irreversible impact of human activities on the environment. The deterioration of natural assets could be caused by current production activities, consumption activities or by (scraps of) produced assets (Bartelmus et al 1992). On this note, the Adjusted GNE (1) is developed to include government defensive expenditure in the Neo-classical framework of income accounts in order to illustrate the relationship between selected macro-variables and expenditure on protecting the environment.

4.3.1 Basic equations for adjusted GNE (1)

As in the Unadjusted GNE model, it is again assumed that all households are infinitely-lived and identical. Now let the current period utility depend on goods and services consumed C_t^w and leisure L_t^w. The utility function is assumed to be

$$E_t \sum_{j=0}^{\infty} \beta^j \left(C_{t+j}^w, L_{t+j}^w\right) \tag{4.23}$$

To differentiate the variables from the previous model, a superscript w is used for variables in the Adjusted GNE (1) model. In equation (4.23) variable C_{t+j}^{w} is defined as effective consumption or adjusted consumption expenditure. Effective consumption is related to actual private consumption as follows:

$$C_t^w = C_t + \theta_1 G_{1t} + \theta_{31} G_{31t} \qquad (4.24)$$

where C_t is private consumption of goods and services. Here G_{1t} represents the expenditure of the government on goods and services that substitutes partially for private consumption. Examples of this kind of expenditure include medical services, public parks, cultural shows *etc*. Without government provision for these goods and services, households have to purchase them from the private sector. Likewise, G_{31t} represents government defensive expenditure on goods and services which substitutes partially for private consumption. Garbage collection expenditure and sewerage are good examples of this kind of expenditure. If the government does not supply these services, the households have to buy them from private firms. In addition government's supply of environmental services will greatly affect the variety and quantity of output available for consumption. As pointed out by Harris and Ulph (1977), the supply of environmental services by the government relates not simply to the achievement of particular technical environmental quality objectives, but also to the options available to consumers. One way of viewing this situation is to consider the damage in the absence of government defensive expenditure. Without government defensive expenditure soil quality may deteriorate and thus lead to a reduction in output levels. Another example is the case where environmental pollution leads to ecological costs in various situations, eg. through the death of forests or the contamination of ground water. These examples are additional societal costs associated with environmentally unsound production. Thus, here it is assumed that effective consumption is a function not only of private consumption expenditure C_t but of government expenditure on goods and services G_{1t} and government defensive expenditure G_{31t}.

The parameters θ_{1t} and θ_{31t} represent the degree of substitutability between C_t and G_{1t}, and C_t and G_{31t} respectively. The value θ_{1t} of and θ_{31t} has an absolute value of 0 to 1. A zero (0) value for the parameter θ_{31t} means that the households do not consider the goods and services provided by the government to correct or prevent environmental deterioration as analogous with that provided by the private sector.

Unlike the Unadjusted GNE model, the production function is postulated as

$$Y_t^w = g(G_{31t}, G_{32t}) f(n_t^d, k_t^d) \qquad (4.25)$$

where

$g(G_{31t}, G_{32t}) > 1$ *when the government's environmental program is successful*

$g(G_{31t}, G_{32t}) < 1$ *when the government's environmental program is not successful*

where Y_t^w is the output of the economy's single good during period t, with n_t^d and k_t^d denoting labour and capital inputs used during period t by the household. The equation implies that there is only one final good in the economy and it is produced according to a constant returns to scale Neo-classical production technology. By Neo-classical we mean that the function $f(.)$ is homogeneous of degree one, strictly concave and with positive but diminishing marginal products. Furthermore, Y_t^w represents the adjusted production function when defensive expenditure are taken into account. Variable G_{31t} refers to government current outlay on defensive expenditures while G_{32t} represents government capital outlay on defensive expenditures. The value of the function $g(G_{31}, G_{32})$, which refers to government compensatory costs, is greater than 1 when the government's programs to protect the environment are successful. Compensatory costs, otherwise known as government defensive expenditures, are the regrettable necessities of production and consumption. The purpose of government defensive expenditure is either to compensate for past environmental damage or to prevent its occurrence in the future. Most often, government policies react to environmental problems. In some cases, environmental protection laws require firms to reduce environmental damage and bear some of the environmentally related costs. In instances where the government's programs to minimise and correct environmental damage are not successful, the value of $g(G_{31t}, G_{32t})$ is less than 1. Unsuccessful government programs would not prevent environmental damage from happening and thus may reduce the output of the economy.

In this simple Neo-classical framework, output is divided into consumption C_t^w and gross investment I_t^w, and capital stock evolves according to

$$k_{t+j}^w = [(1-\delta)k_t + I_t^w] \tag{4.26}$$

where δ is the constant rate of depreciation of capital and I_t^w is the effective level of investment, which is given by

$$I_t^w = I_t + \theta_2 G_{2t} + \theta_{32} G_{32t} \tag{4.27}$$

where G_{2t} is government investment expenditure, which is assumed to substitute for private investment. The variable G_{2t} represent government defensive expenditure on capital. The parameters θ_i, i=2,32 are designed to capture the degree of substitutability between private investment and government investment. The value of θ_i ranges from 0 to 1. A value of 1 for the parameters means that households and private firms perceive government expenditure as equivalent to the investment provided by the private sector.

Equation (4.28) shows the constraint faced by the household agent in time t. The household income is given by

$$g(G_{31t}, G_{32t}) f(n_t^d k_t^d) - w_t n_t + q_t k_t$$

Because expenditure must equal income

$$C_t + I_t + w_t n_t^d + q_t k_t^d + T_t = g(G_{31t}, G_{32t}) f(n_t^d k_t^d) + w_t n_t + q_t k_t \qquad (4.28)$$

where w_t refers to real wage, q_t refers to real rental rate on capital services and T_t refers to a lump-sum tax. The right-hand side of the equation simply means that the sources of funds for the household are output produced plus the values of labour and capital services sold on the competitive market. On the other hand, the uses of funds are consumption, investment (storage of goods) and the hiring of labour and capital services.

The representative agent also faces a resource constraint on time which is

$$L_t^w + n_t = 1 \qquad (4.29)$$

with the endowment of time available in each period normalised to unity.

The Unadjusted GNE government's budget is further modified as

$$G_t = G_{1t} + G_{2t} + G_{31t} + G_{32t} = T_t \qquad (4.30)$$

where it is assumed that lump-sum taxation and a balanced budget prevail in each period. As defined earlier, G_{1t} , G_{2t} G_{31t} and G_{32t} are government expenditure on goods and services, government investment, government current outlay on defensive expenditure and government capital outlay on defensive expenditure, respectively. The main motivation for distinguishing G_{it}, $i=1,2,31,32$ is to highlight the government defensive expenditure and its relationship to consumption, investment and leisure.

The constraints were rewritten to reduce the number of choice variables, by combining equations (4.24) to (4.30), to get

$$\begin{aligned} &C_t + I_t + w_t n_t^d + q_t k_t^d + (1-\theta_1)G_{1t} + (1-\theta_2)G_{2t} \\ &+ (1-\theta_{31})G_{31t} + (1-\theta_{32})G_{32t} = \\ &g(G_{31}, G_{32}) f(n_t^d k_t^d) + w_t n_t + q_t k_t \end{aligned} \qquad (4.31)$$

The above constraints simply state that at time t, the household acts to maximise equation (4.23) subject to a sequence of constraints of the form given by equation (4.31). In other words, the households want to maximise utility by choosing n_{t+j}, C^{w}_{t+j}, I^{w}_{t+j}, n^{d}_{t+j} and k^{d}_{t+j} subject to the sequence of budget constraints given by (4.31).

4.3.2 Model solution for adjusted GNE

Combining the objective function of equation (4.21) and the resource constraints specified by equation (4.29), the Lagrangian equation is

$$\begin{aligned}\mathcal{L} = E_t \sum_{j=0}^{\infty} \beta^j u(C^{w}_{t+j}, L^{w}_{t+j}) + \lambda_{t+j}[C^{v}_{t+j} + k_{t+j+1} - (1-d)k_{t+j} \\ + (1-\theta_1)G_{1,t+j} + (1-\theta_2)G_{2,t+j} + (1-\theta_{31})G_{31,t+j} + (1-\theta_{32})G_{32,t+j} \\ - g(G_{31,t+j}, G_{32,t+j}) f(n^{d}_{t+j}, k^{d}_{t+j}) + w_{t+j}(n^{d}_{t+j} - n_{t+j}) \\ + q_{t+j}(k^{d}_{t+j} - k_{t+j})]\}\end{aligned} \qquad (4.32)$$

The $u(.)$ and $f(.)$ functions have been specified so that corner solutions will be avoided. The first order conditions for maximising equation (4.32) subject to equation (4.31) are as follows:

w.r.t. C^{w}_{t+j} $\quad E_t u_1(C^{w}_{t+j}, 1-n_{t+j}) - E_t \lambda_{t+j} = 0$ (4.33a)

w.r.t. n_{t+j} $\quad -E_t u_2(C^{w}_{t+j}, 1-n_{t+j}) + E_t(\lambda_{t+j} w_{t+j}) = 0$ (4.33b)

w.r.t. n^{d}_{t+j} $\quad E_t\left[g(G_{31t+j}, G_{32t+j}) f_1(n^{d}_{t+j}, k^{d}_{t+j})\right] - E_t w_{t+j} = 0$ (4.33c)

w.r.t. k^{t}_{t+j} $\quad E_t\left[g(G_{31t+j}, G_{32t+j}) f_2(n^{d}_{t+j}, k^{d}_{t+j})\right] - E_t q_{t+j} = 0$ (4.33d)

w.r.t. k_{t+j+1} $$\begin{aligned}-E_t(\lambda_{t+j}) + E_t \beta \lambda_{t+j+1}[g(G_{1,t+j+1}, G_{32,t+j+1}) \\ f_2(n^{d}_{t+j+1}, k^{d}_{t+j+1}) - (1-\delta) = 0\end{aligned} \qquad (4.33e)$$

Here λ_{t+j} is the Lagrangian multiplier associated with the period $t+j$ budget constraints. It can also be interpreted as the discounted utility that can be obtained from the extra unit of a good in period $t+j$, that is the shadow price.

The above conditions are necessary and sufficient for an optimum condition. The interpretations of the equations are the same as those in section 4.2. Likewise, the transversality condition, concerning the long-term accumulation of capital has to be included.

$$\lim_{j\to\infty} E_t\, \beta^{j-1}\, \lambda_{t+j}\, k_{t+j+1} = 0 \qquad (4.33f)$$

Since λ_{t+j} is the utility value of a unit of capital acquired in period $t+j$, $\beta^{j-1}\, \lambda_{t+j}\, k_{t+j+1}$ is the present value of capital held by the household at the end of the period $t+j$. Condition (4.33f) serves to rule out the possibility that the household would forever accumulate capital at an excessive rate, something which is not stipulated by any of the other conditions (Sargent 1987).

At equilibrium, the market can be characterised as $\sum n_t^d = \sum n$ for labour and $\sum k_t^d = \sum k$ for capital. These relationships imply that the quantity supplied and demanded of labour and capital are equal. In addition, it is assumed that households are alike from which it follows that $n_t^d = n_t$ and $k_t^d = k_t$.. Furthermore, these conditions allow aggregation of households.

Using the Neo-classical framework of income accounts, the relationship between consumption and income can be written as:

$$\begin{aligned} Y_t^w &= C_t + I_t + G_t \\ &= C_t^w + I_t^w + (1-\theta_1)G_{1t} + (1-\theta_2)G_{2t} \\ &\quad + (1-\theta_{31})G_{31t} + (1-\theta_{32})G_{32t} \\ &= g(G_{31}, G_{32}) f(n_t^d, k_t^d) \end{aligned} \qquad (4.34)$$

which simply means that at equilibrium, income is equal to aggregate expenditure. Similarly we can express capital stock equation as follows:

$$k_t = k_t^d = (1-\delta)k_{t-1} + I_t^w$$

It is assumed that expectations are rational, so that the conditional mathematical expectations in equation (4.33e) are based on probability distributions that coincide with the economy's structure represented by the model for Adjusted GNE (1).
Consequently, market equilibrium conditions can be characterised by the following set of equalities:

$$u_1(C_{t+j}^w, 1-n_{t+j}) - \lambda_{t+j} = 0 \tag{4.35a}$$

from equation (4.33a)

$$u_2(C_{t+j}^w, 1-n_{t+j}) - \lambda_{t+j} g(G_{31t+j}, G_{32t+j}) f(n_{t+j}, k_{t+j}) = 0 \tag{4.35b}$$

from equations (4.33b) and (4.33c)

$$-\lambda_{t+j} + E_t\left[\beta\lambda_{t+j+1}\left\{g(G_{31t+j+1}, G_{32t+j+1}) f_2(n_{t+j+1}, k_{t+j+1}) - (1-\delta)\right\}\right] = 0 \tag{4.35c}$$

from equation (4.33e)

$$\begin{aligned} C_t^w + I_t^w = g(G_{31t}, G_{32t}) f(n_t^d, k_t^d) - [&(1-\theta_1)G_{1t} + (1-\theta_2)G_{2t} + \\ &(1-\theta_{31})G_{31t} + (1-\theta_{32})G_{32t}] \end{aligned} \tag{4.35d}$$

from equation (4.31)

To lend concreteness to the discussion, consider a specific utility and production functions to derive the optimal conditions. The production function and utility functions are of the form

$$\begin{aligned} Y_t^w &= g(G_{31t}, G_{32t}) f(n_t, k_t) \\ &= g(G_{31t}, G_{32t}) n_t^{\alpha} k_t^{1-\alpha} \end{aligned} \tag{4.36}$$

$$u(C_t^w, 1-n_t) = \phi_1 \ln C_t^w + \phi_2 \ln(1-n_t) \tag{4.37}$$

In this specific example the production function and the utility function are of the Cobb-Douglas and log-linear forms respectively. In addition, it is assumed in this example that capital requires a complete depreciation rate (100 percent) within a single period, that is, it requires that $\delta = 1$.

When the above conditions are imposed, the system of equations given by (4.35a)—(4.35d) becomes,

$$\frac{\phi_1}{1-n_t} - \lambda_t = 0 \tag{4.38a}$$

from equation (4.35a)

$$\frac{\phi_2}{1-n_t} = \lambda\, g(G_{31t+1}, G_{32t+1})\alpha n_{t+1}^{\alpha-1} k_{t+1}^{1-\alpha} \tag{4.38b}$$

from equation (4.35b)

$$\lambda_t = \beta E_t (1-\alpha)\lambda_{t+1}\left[g(G_{31}, G_{32}) n_{t+1}^{\alpha} k_{t-1}^{-\alpha}\right] \tag{4.38c}$$

from equation (4.35c)

$$\begin{aligned} C_t^w + I_t^w = g(G_{31}, G_{32})(n_t^{\alpha} k_t^{1-\alpha}) - [(1-\theta_1)G_{1t} + (1-\theta_2)G_{2t} \\ + (1-\theta_{31})G_{31t} + (1-\theta_{32})G_{32t}] \end{aligned} \tag{4.38d}$$

from equation (4.35d)

In addition, it is assumed that C_t^w and I_t^w are proportional to $X_t Y_t$. Further, let

$$X_t = \frac{Y_t^w - \left[(1-\theta_1)G_{1t} + (1-\theta_2)G_{2t} + (1-\theta_{31})G_{31t} + (1-\theta_{32})G_{32t}\right]}{Y_t^w}$$

then

$$C_t^w = \delta X_t Y_t^w \tag{4.39}$$

$$I_t^w = (1-\delta) X_t Y_t^w \tag{4.40}$$

Combining equations (4.38a) and (4.38b) results in

$$\frac{\phi_2}{1-n_t} = \frac{\phi_1}{C_t^w}\left[g(G_{31},G_{32})\alpha n_t^{\alpha-1}k_t^{1-\alpha}\right] \tag{4.41}$$

$$\frac{\phi_2}{1-n_t} = \frac{\phi_1}{\delta X_t Y_t^w}\left[g(G_{31},G_{32})\alpha n_t^{\alpha-1}k_t^{1-\alpha}\right]$$

but then $n_t^{\alpha-1}k_t^{1-\alpha}$ can also be expressed as $\frac{Y_t}{n_t}$. Next, equation (4.39) is substituted into equation (4.41) to get

$$\frac{1-n_t}{n_t} = \frac{\phi_2\delta}{\alpha\phi_1}\left\{1-\frac{\left[(1-\theta_1)G_{1t}+(1-\theta_2)G_{2t}+(1-\theta_{31})G_{31t}+(1-\theta_{32})G_{32t}\right]}{Y_t^w}\right\}$$

Therefore, by substituting X_t expression in the equation and by defining $G_{1t}/Y_t^w = g_{1t}$, $G_{2t}/Y_t^w = g_{2t}$, $G_{31t}/Y_t^w = g_{31t}$ and $G_{32t}/Y_t^w = g_{32t}$, the equation becomes

$$\begin{aligned}\frac{Leisure}{Labour} = \frac{1-n_t}{n_t} = x_t &= \frac{\phi_2\delta}{\alpha\phi_1} - \frac{\phi_2\delta(1-\theta_1)}{\alpha\phi_1}g_{1t}^w - \frac{\phi_2\delta(1-\theta_2)}{\alpha\phi_1}g_{2t}^w \\ &\quad - \frac{\phi_2\delta(1-\theta_{31})}{\alpha\phi_1}g_{31t}^w - \frac{\phi_2\delta(1-\theta_{32})}{\alpha\phi_1}g_{32t}^w \\ &= \beta_0 + \beta_1 g_{1t}^w + \beta_2 g_{2t}^w + \beta_3 g_{31t}^w + \beta_4 g_{32t}^w\end{aligned} \tag{4.42}$$

where

$$\beta_0 = \text{constant term} = \frac{\phi_{2\delta}}{\alpha\phi_1}$$

$$\beta_1 = \frac{\phi_2\delta(1-\theta_1)}{\alpha\phi_1}$$

$$\beta_2 = \frac{\phi_2\delta(1-\theta_2)}{\alpha\phi_1}$$

$$\beta_3 = \frac{\phi_2\delta(1-\theta_{31})}{\alpha\phi_1}$$

$$\beta_4 = \frac{\phi_2\delta(1-\theta_{32})}{\alpha\phi_1}$$

which simply means that the leisure-labour ratio c_t^w is a function of government expenditure on goods and services, government investment expenditure and government defensive expenditure.

Using equation (4.39) and the same assumptions used to derive equation (4.42), the c_t^w function becomes:

$$
\begin{aligned}
C_t^w &= \delta X_t Y_t^w \\
c_t^w &= \delta X_t \\
c_t^w &= \delta\left\{1-\frac{\left[(1-\theta_1)G_{1t}+(1-\theta_2)G_{2t}+(1-\theta_{31})G_{31t}+(1-\theta_{32})G_{32t}\right]}{Y_t^w}\right\} \\
c_t^w &= \delta-\delta(1-\theta_1)g_{1t}^w-\delta(1-\theta_2)g_{2t}^w-\delta(1-\theta_{31})g_{31t}^w-\delta(1-\theta_{32})g_{32t}^w \\
&= \beta_0+\beta_1 g_{1t}^w+\beta_2 g_{2t}^w+\beta_{31} g_{31t}^w+\beta_{32} g_{32t}^w
\end{aligned}
\tag{4.43}
$$

where

$$
\begin{aligned}
\beta_0 &= \text{constant term } = \delta = 1-\beta+\beta\alpha \\
\beta_1 &= \delta(1-\theta_1) = (1-\beta+\beta\alpha)(1-\theta_1) \\
\beta_2 &= \delta(1-\theta_2) = (1-\beta+\beta\alpha)(1-\theta_2) \\
\beta_3 &= \delta(1-\theta_3) = (1-\beta+\beta\alpha)(1-\theta_3) \\
\beta_4 &= \delta(1-\theta_4) = (1-\beta+\beta\alpha)(1-\theta_4)
\end{aligned}
$$

Equation (4.43) means that effective consumption is a function of government expenditure on goods and services, government investment and government defensive expenditure. A detailed derivation is presented in **Appendix A**.

Similarly, from equation (4.40) the investment function was derived to be of the form

$$
\begin{aligned}
I_t^n &= (1-\delta)X_t Y_t^n \\
i_t^n &= (1-\delta)X_t \\
i_t^n &= (1-\delta)\left\{1-\frac{\left[(1-\theta_1)G_{1t}+(1-\theta_2)G_{2t}\right]}{Y^w}\right\}
\end{aligned}
$$

$$
\begin{aligned}
i_t^n &= (1-\delta) - (1-\delta-\theta_1+\delta\theta_1\ g_{1t} - (1-\delta-\theta_2+\delta\theta_2)g_{2t} \\
&\quad - (1-\delta-\theta_{31}+\delta\theta_{31})g_{31t} - (1-\delta-\theta_{32}+\delta\theta_2)g_{32t} \\
&= \beta_0 + \beta_1 g_{1t}^w + \beta_2 g_{2t}^w + \beta_{31} g_{31t}^w + \beta_{32} g_{32t}^w
\end{aligned}
\tag{4.44}
$$

where

$$\beta_0 = \text{constant term} = (1-\delta) = \beta - \beta\alpha$$

$$\beta_1 = (1-\delta-\theta_1+\delta\theta_1) = (\beta-\beta\alpha)(1-\theta_1)$$

$$\beta_2 = (1-\delta-\theta_2+\delta\theta_2) = (\beta-\beta\alpha)(1-\theta_2)$$

$$\beta_3 = (1-\delta-\theta_3+\delta\theta_3) = (\beta-\beta\alpha)(1-\theta_3)$$

$$\beta_4 = (1-\delta-\theta_4+\delta\theta_4) = (\beta-\beta\alpha)(1-\theta_1)$$

Equations (4.42), (4.43) and (4.44) will form the basis of the derivations presented in Chapter 5. The primary aim will be to establish the relationships that exist between the different components of government expenditure namely, g_{1t}^w, g_{2t}^w, g_{3t}^w and g_{32t}^w and effective consumption (c_t^w), effective investment (i_t^w) and leisure-work ratio (x_t^w). The adjusted Gross National Expenditure will also be computed through the use of simulation.

4.4 Model 3: Adjusted GNE (2)

A second way to adjust GNE is to include the value of leisure in the computations. People, on average, now enjoy more leisure time and longer lives than they did ten years ago. It would be unfortunate to leave these changes out of the income accounts altogether, for they might be more important to the representative household than the change in the quantities of goods and services consumed. Consider a case where two individuals earn the same wage but person A works seven hours a day while person B works nine hours a day. Here we could say that person A's income broadly conceived is higher than person B's. The same analogy could be applied at the macro level.

The theory of leisure, as reviewed in the previous chapter, is used as the basis for methods developed for this study. The different attempts to impute for the value of leisure in the estimation of American economic growth were presented in Chapter 3.

In addition, the following assumptions are postulated

- Leisure consists only of the hours devoted to this activity, and not the hours devoted to non-market activities such as vegetable gardening and do-it-yourself activities.

- Following ABS (1993), the number of hours of leisure is the difference between (the total number of hours available for work plus discretionary work plus leisure) and (the number of hours worked per week)

- The increase or decrease in the number of hours of leisure, as compared with the base year, is correctly reflected by the decrease in the number of hours worked.

- There is no change in the number of hours of leisure of people who are classified as not being at work.

The different ways of imputing for the value of leisure were discussed in detail in Chapter 3. The classifications are presented again in Table 4.1.

The different concepts used to impute for the value of leisure will be discussed further in this section. To illustrate, suppose that leisure is an aspect of welfare that is not part of income. In this case, consumption has to be redefined to include a premium for increases or decreases in leisure since the previous year in order to impute for the value of leisure in the measure of GNE. Unlike Usher, here it is assumed that the individual is trying to at least approximate his or her leisure level from the previous

Table 4.1
Methods to Impute for the Value of Leisure

Concept of Leisure Hours	**Concept of Leisure Value**	
	Average Wage	Marginal Wage
Total Quantity of Leisure	$\hat{Y}_t^3$	$\hat{Y}_t$
Marginal Quantity of Leisure	$\hat{Y}_t^4$	$\hat{Y}_t^2$

year. This assumption was made because infrafamily allocation of time studies show that the number of hours spent on household activities have been increasing faster than the fall in the number of hours work. This implies that the number of hours available for leisure has been decreasing. Mathematically, the relationship is expressed as

$$U(\hat{C}_t, L_{t-1}) = U(C_t, L_t) \tag{4.45}$$

where

$\hat{C}_t$ = real consumption inclusive of the imputation for leisure

L_{t-1} = hours of leisure in the previous year

C_t = real consumption without the imputation for leisure

L_t = hours of leisure in year t

Assuming further that $C_t = Y_t$, that is, real income of the representative agent is equal to its real consumption expenditure, then real income inclusive of the imputation for leisure is defined as

$$U(\hat{Y}_t, L_{t-1}) = U(Y_t, L_t) \tag{4.46}$$

where

$\hat{Y}_t$ = real income inclusive of the imputation for leisure using real wage rate

Y_t = real income without the imputation for leisure

Equation (4.46), approximated by the first term of its Taylor series around the point (Y_t, L_t), is transformed into

$$\hat{Y}_t = Y_t + w_t(L_t - L_{t-1}) \tag{4.47}$$

where w_t is the real wage in year t (average wage). Specifically, w_t is defined as the rate of trade-off between goods and the hours of labour.

The concept of a person's productivity per hour of leisure (denoted as variable Z_t) is a 'tricky' one. The assertion that productivity per hour of leisure is increasing overtime does not only mean that the household is having more fun per hour than it used to because of the current consumption goods such as television, motor boats, *etc.*, but it also means that as a consequence of people's higher accumulated knowledge and greater stock of human capital, the household get more benefit per hour of leisure than their grandparents had they have access to the same goods and services. To incorporate the different assumptions associated with the productivity of leisure Z_t , equation (4.47) can be rewritten as

$$\hat{Y}_t = Y_t + \frac{w_t}{Z_t}(L_t Z_t - L_{t-1} Z_{t-1}) \tag{4.48}$$

where productivity of leisure Z_t would have a value that ranges from zero to infinity. In this study leisure productivity is constant and thus Z_t is assumed to be equal to one, for all t. The rationale behind this assumption is that the progress of the Australian economy depends primarily on the people's capacity to make things rather than on the people's capacity to enjoy them.

As a variant of equation (4.48), the variable w_t can be redefined as marginal wage rate such that

$$\hat{Y}_t^2 = Y_t + \frac{m_t}{Z_t}(L_t Z_t - L_{t-1} Z_{t-1}) \tag{4.49}$$

where

$\hat{Y}_t^2$ = real income inclusive of the imputation of leisure using marginal wage rate

m_t = marginal wage rate

Another imputation for the value of leisure is attempted by using the alternative:

$$\hat{Y}_t^3 = Y_t + \frac{w_t}{Z_t}(L_t) \tag{4.50}$$

where

$\hat{Y}_t^3$ = real income inclusive of the imputation of leisure using average wage rate and total leisure hours

Finally, the value of leisure is computed using the concepts of marginal wage rate and total leisure hours. Thus, the equation becomes

$$\hat{Y}_t^4 = Y_t + \frac{m_t}{Z_t}(L_t) \tag{4.51}$$

where

$\hat{Y}_t^4$ = real income inclusive of the imputation of leisure using marginal wage rate and total leisure hours

The various ways proposed to impute for the value of leisure are attempted in Chapter 8 of this study. The methods will be evaluated to determine the best possible procedure given the data.

4.5 A Summary

This chapter outlines the models developed for this research in an intuitive manner. No formal proof of the relevant propositions is provided at this stage. The derived models are extended versions of the model developed by McCallum (1989). The first model extends the McCallum model by integrating the government sector and the environment with the real business cycle model. The second model proposed incorporates government defensive expenditure in specifying the production function. The third model expands the second model by imputing for the value of leisure.

The value of leisure is based on equations (4.48) to (4.51). This study attempts four ways of imputing for the value of leisure. The first method uses marginal quantity of leisure and average wage. The second employs marginal quantity of leisure and marginal wage. The third applies average wage and total leisure concept, while the last method proposed uses total quantity of leisure and the marginal wage. The first two methods would be used to determine welfare changes from year to year and the latter two methods would be useful in computing total welfare changes from year to year.

5. DATA COLLECTION

The ABS will continue to investigate other statistical frameworks for presenting environmental statistics.
(ABS 1993)

5.1 Introduction

This chapter describes the data requirements as well as the way data were collected for this study. Section 5.2 deals with the data taken from the Australian National Accounts (ANA). A detailed description of the variable for government defensive expenditure is given in Section 5.3. Section 5.4 discusses the data needed to impute for the value of leisure. The distribution procedure used to generate quarterly observations for some variables detailed in Section 5.5. Finally, a summary is presented in Section 5.6.

5.2 Sources of Data

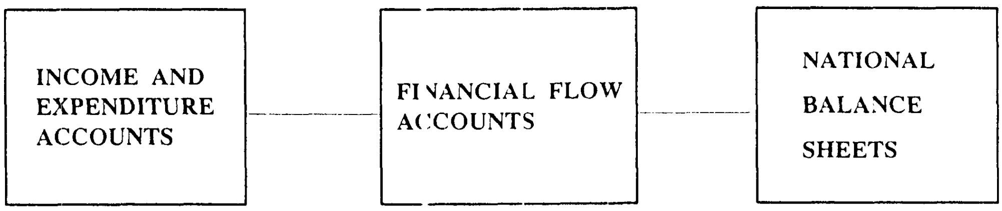
5.2.1 Description of the Australian National Accounts

The national accounts provide a systematic framework for summarising and analysing economic transactions within a nation. The ANA is based on the principles expounded in the 1968 edition of the United Nations publication, A System of National Accounts (SNA). These principles are widely adopted by government statistical agencies throughout the world. A complete set of national accounts would include both flow accounts (for production, income or expenditure for a given period) and a set of balance sheets. The balance sheet records the nation's assets and liabilities. The unit of valuation throughout is dollars expressed in either the current or in the base period.

The three major components of the ANA are shown in Figure 5.1. The first is known as the Income and Expenditure Accounts (including the measure of Gross Domestic Product), the second is called the Financial Flow Accounts, and the third is the National Balance Sheet. The Income and Expenditure Accounts are published quarterly in *ABS Catalogue No. 5206.0 Australian National Accounts: National*

Income, Expenditure and Product. The Financial Flow Accounts with estimates of Australia's financial assets and liabilities, are published quarterly in *ABS Catalogue No. 5232.0 Australian National Accounts: Financial Accounts*. While Australia has a comprehensive set of flow accounts, it has not yet compiled a full balance sheet account. To date, estimates of the value of manufactured assets (buildings and equipment), and the value of real estate transfer expenses have been published, with data up to and including 1991-1992 (ABS catalogue No. 5221.0, *Australian National Accounts: Capital Stock*). In line with changes in *A System of National Accounts*, the Australian balance sheet accounts will be extended to include specific natural resources.

Figure 5.1
The System of National Accounts



The present ANA fail to reflect adequately the effect of economic activity on the environment (ABS 1990a). The failure occurs in three particular respects.

(1) When a natural resource is discovered, or harvested, there is no record of this fact. Discoveries increase the productive capacity of the economy and should be included as an addition to national income. Likewise, an increase in harvest should be treated as a depreciation and should be subtracted from the national income.

(2) There is no measure of sustainable' income. If a measure of sustainable income is required, measured income should be offset by the extent to

which natural resources are used up when income is generated.

(3) There is no adjustment made for the effects of pollution and in particular for activities designed to protect or repair the environment. Expenditure to protect the environment are recorded as final expenditure and thus increases real GDP.

The accounts also fail to allow for the changes in leisure. As stated earlier, the omission of leisure is partly explained by the fact that leisure is purchased by not working rather than by spending and trading. The inclusion of leisure to extend the GNP measure is based on the fact, that time, like environmental resources, is limited. Increases in leisure, ceteris paribus, will lead to an increase in welfare.

5.2.2 Current developments in the ANA

The ABS established the Environment and Natural Resource Statistics Unit in June 1991 to allow the Bureau to assume a statistical role in the increasingly important area of the environment.

Since the publication of the Framework for the Development of Environment Statistics (FDES), Australia has published two statistical reports on the environment. One is entitled *Australia's Environment: Issues and Facts in 1992*. The purpose of this publication was to provide a set of statistical benchmarks for debate on environmental issues at both the national and international level. The second report is called the *Cost of Environment Protection, Australia: Selected Industries 1990-1991* and was published in January 1994. The publication presented data on costs incurred by manufacturing and mining industries and the government for the protection of the environment.

5.2.3 Definitions and relationships between income concepts

The ANA is founded on a widely accepted theoretical model, and all parts and variables are connected through accounting identities. Money is the common unit of measure and the concepts, definitions and classifications of the system are widely accepted. The main concepts of product, income and expenditure in the ANA are defined and expressed as follows (ABS 1990b).

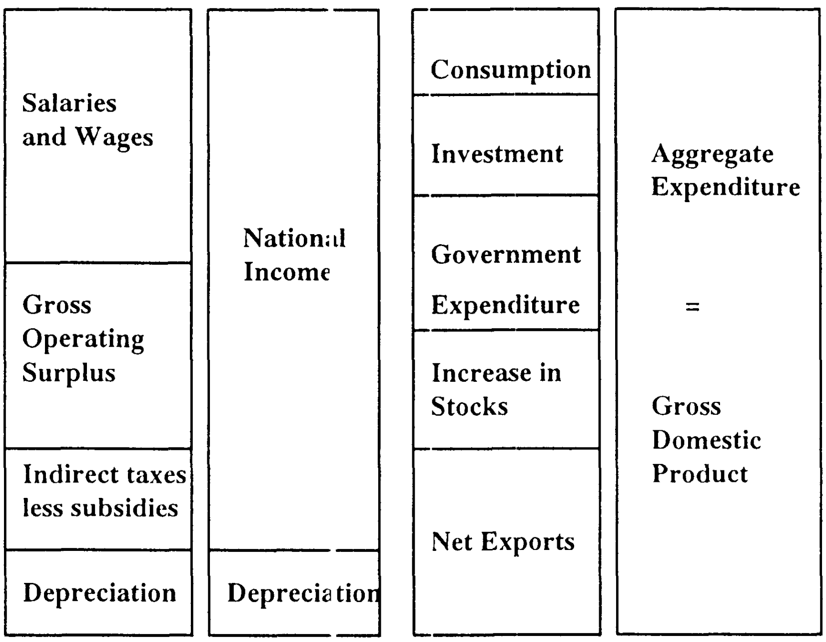
Gross Domestic Product is defined as the income generated by production taking place within Australia's domestic territory. If an allowance for the consumption of fixed capital is deducted from GDP, the resulting measure is **Net Domestic Product**.

National Income is the net income accruing within a given period to Australian residents from their services in supplying factors of production (labour, land, capital and enterprise) in Australia or overseas, plus indirect taxes but less subsidies. It is equivalent to **Domestic Factor Income** plus indirect taxes less subsidies, and net income paid overseas.

Domestic Factor Income is by definition the sum of salaries and wages, and gross operating surplus.

Figure 5.2

The Relationship between the Main Identities of Gross Domestic Product



Adapted from ABS (1990b)

The relationships between these concepts are illustrated in Figure 5.2. Each bar in Figure 5.2 is equal to GNP. No conclusions concerning the relative magnitude of the various aggregates can be drawn from the diagram, especially as some of the boxes may represent negative values.

The sum of private and government final consumption expenditure, and gross capital expenditure, is often referred to as **Domestic Final Demand**. In the ANA, the sum of domestic final demand and the increase in stocks is shown as **Gross National Expenditure** (GNE). In the analysis, GNE will be used in lieu of GDP, as explained in Chapter 4.

5.2.4 Specific data requirements

At least thirty observations (In *et al* 1992) are needed for a full analysis of the long-run relationships among the variables. Since there were only 30 years of annual observations, quarterly observations were used in the analysis. Quarterly data were collected for the following variables:

- government final consumption expenditure on goods and services (G_1),
- government investment expenditure (G_2)
- private consumption expenditure (C)
- private investment expenditure (I)
- gross national expenditure (GNE)

A thirty-year time span, of 116 quarterly observations of these variables were used. A quarterly series of seasonally-adjusted data and the consumer price index, from 1966 to 1992 were collected from *ABS Catalogue No. 5206.0 Australian National Accounts: National Income, Expenditure and Product.* To remove the effect of inflationary trends in an attempt to stabilise the data, all values were deflated into constant prices with 1989-1990 as the base year. The deflator used was the consumer price index.

In the ANA, the variable

- G_1 **(government final consumption expenditure)** represents the general everyday running costs of government departments and non-business authorities.

- G_2 (**public gross fixed capital expenditure**) usually refers to large and expensive items which are intended to last several years.

- C (**private final consumption expenditure**) is basically the amount spent by households in their everyday living. It includes amounts spent on items such as food and clothing, but also includes expenditure on items purchased less frequently such as cars, TVs, video recorders and washing machines.

- I (**private gross fixed capital expenditure**) is often referred to as investment. It encompasses dams, buildings, computing equipment, aircraft, ships and locomotives, *etc*.

Increase in stocks, which is a component of GNE, includes finished goods which are awaiting sale in shops and factories, and partly finished goods and materials awaiting processing.

5.3 Government Defensive Expenditure

Research studies on the macroeconomic relationships among macroeconomic variables have not used the concept of government defensive expenditure. Government defensive expenditure represents the costs of activities to protect against the unwanted side-effects of production and consumption on the environment. The ABS defined government defensive expenditure as expenditure undertaken to protect the environment from damage incurred during economic activity (ABS 1990). Unlike other studies on the national accounts, in this study, government expenditure is further classified into four components namely government expenditure on goods and services (G_{1t}), government investment expenditure (G_{2t}), government defensive expenditure on goods and services (G_{31t}) and government defensive expenditure on investment (G_{32t}). The primary reason for classifying government expenditure into these four categories is to determine the amount that the government spend on the environment. Another reason for the reclassification of government expenditure into four components is the need to identify that part of GNE which reflects the costs necessary to compensate the negative impacts of economic growth (defensive expenditure) and that part of GNE that increases real income (Leipert 1989). A further purpose is to determine the relationship between each individual component of government defensive expenditure and c_t^w (private consumption expenditure), i_t^w (private investment expenditure), g_{1t}^w (government expenditure on goods and services), g_{2t}^w (government investment expenditure) and x_t^w (leisure-labour ratio). However, the actual values of (G_{31t}) and (G_{32t}) were very small that it was thought logical to combine the values of the two variables into G_{3t} (total defensive expenditure) in the empirical analysis.

The ABS public accounts data classify government transactions by purpose according to the Government Purpose Classification (GPC). To facilitate international comparisons, the GDP closely follows the principles of the United Nations Classification of the Functions of Government (COFOG). The transactions classified by the GPC represent current and capital outlays and income transfers of public trading enterprises (PTE's). Operating costs of PTE's are not included.

The GPC codes that cover outlays specifically relating to environment protection are as follows:

0720	Water supply
0730	Sanitation and protection of the environment
0731	Household garbage
0732	Other sanitation
0733	Sewerage
0734	Urban stormwater drainage
0739	Protection of the environment not elsewhere classified
0813	National parks and wildlife

Though clear distinctions are not always possible as to what is included in the computations of government defensive expenditure, Table 5.1 identifies the subgroups of expenditure, by the federal, state and local governments of Australia included in the study.

Table 5.1
Classification of Government Defensive Expenditure as per ABS Classification

Notation	Sub-group	Title/Description
	0731	*Household Garbage*
G_{311}	**0731**	*Current outlay on household garbage*
G_{321}	**0731**	*Capital outlay on household garbage*
		Outlays on administration, regulation support etc of household garbage collection and disposal services. It also includes subsidies, grants, advances or other assistance for the development, expansion or operation of household garbage systems.
		Excludes outlays on the administration of regulations on the generation and release of pollutants to the environment and on research and experimental development in the field of sanitary affairs classified as 0739.
	0732	*Other Sanitation*
G_{312}	**0732**	*Current outlay on other sanitation*
G_{322}	**0732**	*Capital outlay on other sanitation*
		Outlays on administration, regulation support etc of sanitary services other than household garbage. Includes trade and industrial trade disposal; cleaning of streets, gutters; foreshores and recreational areas; special rubbish clean-ups and anti-litter enforcement; advances or other assistance for the development, expansion or operation of such systems.
		Excludes outlays on the administration of regulations on the generation and release of pollutants to the environment and on research and experimental development in the field of sanitary affairs classified as 0739.

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	0733	***Sewerage***
G_{313}	**0733**	*Current outlay on sewerage*
G_{323}	**0733**	*Capital outlay on sewerage*

Outlays on administration, regulation, support etc of sewerage collection, treatment and disposal operations. Includes deep mains town systems; effluent drainage systems; septic tank cleaning and inspection; nightsoil disposal; and subsidies grants, grants advances or other assistance for the development , expansion or operation of such systems.

Excludes outlays on the administration of regulations on the generation and release of pollutants to the environment and on research and experimental development in the field of sanitary affairs classified as 0739.

	0734	***Urban stormwater drainage***
G_{314}	**0734**	*Current outlay on urban stormwater drainage*
G_{324}	**0734**	*Capital outlay on urban stormwater drainage*

Outlays on administration, regulation, support, operation etc of urban stormwater drainage services. Includes urban drainage systems and stormwater drains, including the linking or lining of creeks and the provision of open or deep draining systems; and subsidies, grants advances or other assistance for the development , expansion or operation of such systems.

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0734 *Urban stormwater drainage*

Excludes outlays on: construction of drains associated with road works classified as 1211; rural flood mitigation and agricultural drainage classified as 1012; and administration of regulations on the generation and release of pollutants to the environment and on research and experimental development in the field of sanitary affairs classified as 0739.

0735 **Pollution control**

G_{315}	**0735**	*Current outlay on pollution control*
G_{325}	**0735**	*Capital outlay on pollution control*

Covers outlays on the prevention of pollution and on mitigation of its detrimental effects on ecological balance and the state of the environment which cannot be allocated to other purposes.

It also includes outlays on enhancing air-quality, support of development and use of anti pollution devices, support of activities designed to restore or maintain a healthy environment and outlays on related regulatory and research activities.

0736 ***Other environmental protection program***

G_{315}	**0736**	*Current outlay on other environmental protection programs.*
G_{325}	**0736**	*Capital outlay on other environmental protection programs.*

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0736 *Other environmental protection program*

Includes outlays relating to the control and prevention of erosion of beaches and foreshores, construction and maintenance of works to mitigate flooding of urban centres and miscellaneous outlays relating to the protection of the environment, including outlays which cannot be identified with any specific purpose.

Soil and water resource management

Includes grants, subsidies and other assistance for agricultural land clearing, reclamation and the control of soil erosion.

Forest resource management

Includes efforts to conserve, extend or rationalise the exploitation of forest resources, field management, the operation and support of re-afforestation, pest and disease control activities, and forest fire fighting and fire prevention services.

Source: ABS Catalogue 5504.0 *Federal, State and Local Governments Finance Australia*

Government defensive expenditure (G_{3t}) data are not explicitly given in the accounts and hence had to be calculated. In this process, two major data deficiencies emerged. First, although there has been a significant improvement in the availability of data on public sector expenditure, they are not available in sufficient detail after 1978 to compare easily with the classification presented in Table 5.1. Secondly, the Australian Bureau of Statistics (ABS) eliminated a separate entry for soil resource management and forest resource management expenditures in 1979. Thus, expenditures on soil resource management and forest resource management were excluded in the computations of G_{3t}. Furthermore, environment protection expenditures with codes 0720 (water supply), 0730 (sanitation and protection of the environment) and 0813 (national parks and wildlife) were not included due to insufficient data. The value of G_{3t} was calculated for the federal, local and state governments as follows:

Current Outlay on Government defensive expenditures on goods and services (CO_3)

$$CO_{31} = G_{311} + G_{312} + G_{313} + G_{314} + G_{315} + G_{316} \tag{5.1}$$

where the values of all the items are an aggregate of all federal, state and local government current outlay on the following items,

G_{311} = household garbage
G_{312} = other sanitation
G_{313} = sewerage
G_{314} = urban stormwater drainage
G_{315} = pollution control
G_{316} = other environmental protection program

Current outlays refer to the sum of net current expenditure on goods and services and net current transfer payments.

Capital Outlay on Government defensive expenditures on goods and services (CI_{32})

Capital outlays refer to the sum of expenditure on new fixed assets, net purchases of other capital assets (for example building and land), increases in stocks and net transfer payments to other bodies to fund capital expenditure. Likewise, the variable on capital outlay was computed as:

$$CI_{32} = G_{321} + G_{322} + G_{323} + G_{324} + G_{325} + G_{326} \quad (5.2)$$

where the value corresponds to the federal, state and local government capital outlay on the following items

G_{321} = household garbage
G_{322} = other sanitation
G_{323} = sewerage
G_{324} = urban stormwater drainage
G_{325} = pollution control
G_{326} = other environmental protection program

Therefore,

$$G_3 = CO_{31} + CI_{32} \quad (5.3)$$

Since G_3 is already included in both G_1 or G_2, their values have to be adjusted to avoid double counting.

Government expenditure on goods and services (G_1)

$$G_1 = G_1^* - CO_{31} \quad (5.4)$$

where G_1^* = government expenditure on goods and services as reported by ABS

CO_{31} = government defensive expenditure on goods and services

Similarly, Government investment expenditure (G_2) was adjusted as follows

$$G_2 = G_2^* - CI_{32} \tag{5.5}$$

where G_2^* = government capital outlay reported by ABS
CI_{32} = government defensive expenditure on investment

5.4 Data on Leisure Imputation

To impute a value for leisure, following the theoretical model of Chapter 4, data were collected on the following variables:

- average wage rate per week
- number of working hours per week
- number employed
- number unemployed
- marginal wage rate per week.

Quarterly data from 1962.3 to 199 .2 were used in the imputations. All variables were seasonally-adjusted and the data included the weekly wage rate, numbers employed (men and women), numbers unemployed (men and women) and the consumer price index. The basic monetary data, expressed in current prices, were transformed to constant prices using the consumer price index with a base year of 1989-1990.

Data on average wage rate per person were derived by dividing estimates of weekly total earnings by estimates of the number employed and was checked against the ABS entry on average wage rate. As defined by the *Survey of Average Weekly Earnings*, the weekly total earnings of an employees refer to one week's earnings before taxation and other deductions have been made.

Quarterly data for the full period on the average number of hours worked were not available but yearly data were. The possibility that average number of hours follows a constant within-year trend was investigated. The quarterly data for the notified vacancies from the *Commonwealth Employment Services*, 1970 to 1992, were collected and analysed. Only three years out of 24 (December 1985 to September 1988) seem to show some quarterly trend. On this basis, it was assumed that the average number of hours worked per week over a given year does not have a seasonal pattern across the 24 years.

The ABS changed the reporting procedures for average hours worked and average wage rate during the study period, and this could lead to two data deficiencies. First, the weights assigned by the ABS for full and part-time work, when computing the average, were changed in 1979. Second, the weights assigned for men and women were also changed in 1979, and so the basis of the computations of the average hours worked changed again. These changes may cause a bias in favour of part-time and female workers. To test for this bias, a dummy variable (DM) was tested in the econometric model to estimate the marginal wage rate. This procedure will be discussed in detail in Section 5.5. A value of zero was assigned to years 1962 to 1978, and a value of one was given to years 1979 to 1992. The dummy variable was never significant and as such these potential biases do not appear to affect the estimates of marginal wage. The dummy was dropped in the final model.

The real average wage rate per hour was computed by dividing real wages per week by the average hours worked per week. The marginal wage was calculated by dividing the change in total wages by the change in total working hours per quarter. Marginal wage is defined as the cost of hiring one hour of labour.

In Chapter 3, leisure was defined as the time not devoted to work. Total leisure hours per week were calculated from the time-budget study conducted by the ABS (1993), the results of which are given in Table 5.2. The ABS produced the breakdown in minutes per day, and the classification of activities into two classes (a) personal activities and (b) work and leisure activities, was undertaken by the author. There are 168 hours available in a week and the ABS suggest that 94 hours are spent by men on personal activities, such as sleeping, eating, child minding. Likewise, Table 5.2 shows that women spent 110 hours on personal activities, leaving them with a relatively smaller number of hours for leisure..

The number of hours available for work and leisure was calculated as follows.

$$\begin{aligned}\text{Hours of work and leisure for men} &= 168 - 94 \\ &= 74 \text{ hours per week}\end{aligned}$$

Thus for men 74 hours were available for the sum of discretionary work and leisure.

Table 5.2

The Use of Time in Australia, 1992: hours per week

ACTIVITY	MEN	WOMEN
(a) Personal Activities		
Domestic activities	12	22
Child care/minding	2	6
Purchasing goods	4	6
Personal care, eating and sleeping	72	73
Education	4	3
Subtotal	**94**	**110**
(b) Work and Leisure		
Labour force	31*	15*
Voluntary work/community	3*	3*
Social life and entertainment	10*	13*
Active leisure	7*	5*
Passive leisure	22*	22*
Subtotal	**74**	58
Total	**168**	**168**

* These items are included in the calculations for total hours of work and leisure.

Source: ABS Catalogue No. 4153.0 *How Australians Use Their Time*

Likewise, the number of work and leisure hours available for women was calculated as follows.

$$\text{Hours of work and leisure for women} = 168 - 110$$
$$= 58 \text{ hours per week}$$

The 74 hours for men were taken to be the total number of hours available for standard work, discretionary work and leisure. Total leisure hours for men per week were then estimated by subtracting average working hours per week from 74. For instance, if the average working hours per week is 41 hours, total leisure hours is computed by subtracting 41 hours from 74 hours. Thus, total leisure hours is equivalent to 33 hours per week. The total leisure hours per week was then multiplied by the number of employed persons and by 52 weeks, to determine total leisure hours per person per year. This process was repeated for women, with 58 hours available for work.

5.5 Distribution Procedure

5.5.1 Government defensive expenditure

From the published data, the value of G_3 was calculated for the federal, local and state governments using the procedure discussed in Section 5.3. However, G_3 was recorded annually. In order to determine the quarterly values, the distribution method suggested by Chow and Lin (1971) was used. The method used in deriving the quarterly estimates for G_3 is extremely simple. The procedure is summarised as follows.

(1) A quarterly economic series such as G_{2t} and G_{1t} were chosen because they covered the same ground as $G_{3.}$, and G_{3l} (basic series) respectively and were available in seasonally adjusted form.

(2) Annual averages were then computed for the quarterly figures of the basic series for the period 1962 to 1991 inclusive. Since the quarterly figures are seasonally adjusted, the annual figures derived from the quarterly figures were seasonally adjusted. These annual averages of the basic quarterly series were then correlated with the corresponding seasonally adjusted annual data of the variables to be estimated to obtain regression relations with the latter as dependent variables. The detailed results are presented in **Appendix B**. The specific equations were as follows:

$$G_{31t} = -270.55 + 0.0158\ G_{1t} \qquad (5.6)$$
$$(-5.68) \quad (14.59) \qquad R^2 = 0.93$$

$$G_{32t} = 99.76 + 0.0188\ G_{2t} \qquad (5.7)$$
$$(0.30) \quad (4.95) \qquad R^2 = 0.85$$

Since the R^2 were 0.93 for G_{31t} and G_{1t}, and 0.85 for G_{32t} and G_{2t}, it was concluded that the variables that were estimated and the 'basic series' move extremely close together.

(3) Seasonally adjusted quarterly figures for G_{32t}, and G_{31t} were then obtained from the regression relations simply by inserting in these equations the quarterly figures of the 'basic quarterly series'. The equations used to compute for the quarterly values were given by

$$G_{31quarter} = \left(\frac{-270.55}{4}\right) + (0.0158 \times G_{1quarter}) + \left(\frac{residual}{4}\right) \quad (5.8)$$

$$G_{32quarter} = \left(\frac{99.76}{4}\right) + (0.0188 \times G_{2quarter}) + \left(\frac{residual}{4}\right) \quad (5.9)$$

5.5.2 Number of hours worked

With regards to the leisure component of the study, quarterly data on the average number of hours worked were not also available and thus the distribution method was also applied. The 'basic series' first identified for working hours for men (*HWM*) and working hours for women (*HWW*) were wage rate for men (*WRM*) and wage rate for women (*WRW*) respectively. Using the procedure discussed earlier, the specific equations derived were as follows:

$$HWM = 9000.70 - 125.19WRM \quad (5.10)$$
$$(3.18) \quad (-1.76) \qquad R^2 = 0.42$$

$$HWW = 10832.0 - 284.45WRW \quad (5.11)$$
$$(5.94) \quad (-1.76) \qquad R^2 = 0.48$$

Since the R^2 values were very small, it was concluded that the two variables number of hours worked (*HW*) and wage rate (*WR*) did not move closely together. A second 'basic series' was then chosen. The variables number of employed men (*EM*) and number of employed women (*EW*) were then tested but again the R^2 values of the regression were below 0.50.

Commonwealth Employment Services (CES), 1970 to 1992, were observed. However, in only three of the 23 years (December 1985 to September 1988) was there any quarterly trend of troughs and peaks observed. On the basis of this evidence, it was assumed that the average number of hours worked per week over a given year is constant.

5.6 Summary

The nature of the data and data requirements have been discussed in this chapter. A thirty-year time span, of 116 quarterly observations from 1962:3 to 1992:2 was collected for this study. For simplicity the SHAZAM data specification is followed i.e. 1 would refer to first quarter, 2 to second quarter, *etc*. The value of the variable government defensive expenditure is not reported in the national accounts and thus had to be calculated from other ABS publications. In addition, the ABS only publishes an annual value of the variable government defensive expenditure. Thus, a distribution method has been used to derive the quarterly value for government defensive expenditure.

Data on average wage rate per hour per person and marginal wage rate, were required to impute for the value of leisure but they were not readily available. A time-use study for Australia was used to derive total hours available for work and leisure.