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ENVIRONMENTAL TAXATION FOR A SUSTAINABLE FUTURE: PERSPECTIVES FROM ENVIRONMENTAL MACROECONOMICS

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Abstract

The aim of this paper is to demonstrate the significant differences that would emerge in policy formulation, when environmental capital is explicitly accounted for in macroeconomic analyses. These differences are illustrated with reference to the Australian economy. The main analytic frameworks considered are the aggregate demand and supply framework and the factor utilisation function – which traditionally deals with labour and manufactured capital. The development of a three-factor utilisation function in terms of labour, manufactured capital, and environmental capital enables the display of mistaken notions of economic performance. That is in the absence of environmental capital; policy makers over-state the performance of labour and manufactured capital. As illustrated in the paper, the implication of developing and applying environmental-macroeconomics framework for formulating sustainable development policies is significant.

I. Introduction

The aim of this paper is to present a case for the generalized adoption of the environmental-macroeconomics model for policy analysis – specifically, in fiscal policy analysis. This argument is made by recourse to comparing the outcomes of a standard macroeconomic model as against those of an environmental-macroeconomics model. The hypothesis is that the beneficial effects of environmental taxes are understated in a standard macroeconomic model as compared to the environmental-macroeconomics model. This is clearly illustrated in the environmental-macroeconomics model which explicitly accounts for the depreciation of environmental capital. Consider the context where environmental taxes are used to finance an environmental capital investment, which would offset the depreciation of environmental capital. In this context, the overall macroeconomic gains that include the reduction in environmental capital depreciation would be captured in the environmental-macroeconomics model and not the standard macroeconomic model.

The paper is structured as follows. The next section deals with the presentation of the standard macroeconomic and environmental-macroeconomics frameworks, and the basis for testing the hypothesis. In Section III, these frameworks are applied and tested with reference to the Australian economy. For this test, we consider the time series data on macroeconomic aggregates spanning the period 1980 to 2011. We then use these aggregates to estimate trends of pertinent coefficients in our frameworks. Such trends enable the resolution and simulation of specific macroeconomic outcomes, namely income (Y), inflation (π) and employment (L). Central to the test is the insertion of a hypothetical marginal tax for an environmental capital investment for an initial period. We nominate 2011 as this period and then track the possible outcomes that could emerge following the introduction of the tax and its return into the system as an investment. For illustrative purposes, we suppose that the investment is reforestation, which when established would add to the environmental capital sink capacity to sequester greenhouse gas emissions.

II. The Macroeconomic Frameworks

Following Thampapillai and Sinden (2013) and Thampapillai (2012), both the standard and environmental macroeconomic frameworks are exposited in terms of aggregate demand (AD), aggregate supply (AS) and factor-utilization. The differentiating feature between the two frameworks is the presence of environmental capital (KN) and its depreciation in the environmental-macroeconomics framework. AS is differentiated into a short-run function (AS_{SR}) and a capacity function (AS_F). It is assumed that AS_{SR} is strictly Keynesian – that is, as much as output as possible would be endeavoured at a given set of prices. The definition of AD rests on the Fisher-Money equation. A Cobb-Douglas function of constant returns to scale describes factor utilization involving manufactured capital (KM) and labour (L) in the standard framework and in addition KN in the environmental-macroeconomics framework.

The two sets of frameworks are defined below.

The Standard Framework

$$AS_{SR}: \{(\pi = \pi_t) | (Y \to \infty)\} \quad (1)$$

$$AS_F: \{(Y = Y_F) | (\pi \to \infty)\} \quad (2)$$

$$\text{AD:}\quad \pi_t = \left[\frac{M_t V_t}{Y_t P_{t-1}}\right] \qquad (3)$$

In (3), Y is determined by the components of aggregate expenditure as follows:

$$GDP = \Phi + \beta Y (1 - \tau) \qquad (4)$$

In (4): Φ is a constant comprising of investment, government spending and net exports, β, and τ are respectively the marginal propensity to consume and the rate of taxation. Factor utilization is defined as:

$$Y = \alpha KM^{\theta} L^{\lambda} \qquad (5)$$

In (5), θ and λ represent respectively the shares of Y that accrue to KM and L. The assumption of constant returns to scale dictates that $(\theta + \lambda) = 1$. Given that the income statements in national accounts is bound by the identity defining payments to KM – namely Operating Surplus (OS) and payments to L – namely Compensation of Employees (CE), the values of θ and λ can be elicited respectively as: (OS / Y) and (CE / Y).

The Environmental-Macroeconomics Framework

The environmental-macroeconomics framework differs from the standard framework by the recognition of KN in the definition of factor utilisation and that of GDP. That is, expressions in (4) would be redefined as follows:

$$GDP = (1 - \eta)\{\Phi + \beta Y (1 - \tau)\} \qquad (6)$$

In (6), η is the share expenditures in GDP that account for the depreciation of KN – namely D_{KN}. The definition of factor utilization now becomes:

$$Y = (1-\eta)\ \alpha\ (KM + KN)^{\theta}\ L^{\lambda} \tag{7}$$

Note that should ($KN \rightarrow 0$), then ($D_{KN} \rightarrow 0$) and hence ($\eta \rightarrow 0$). In such a context (6) and (7) would revert to (4) and (5). The basis for the formulation in (7) is provided in Thampapillai (2012) and rests on the recognition of the principles of entropy and ecological resilience.

Both the standard macroeconomic and environmental-macroeconomics frameworks are illustrated in Figures 1 and 2 respectively.

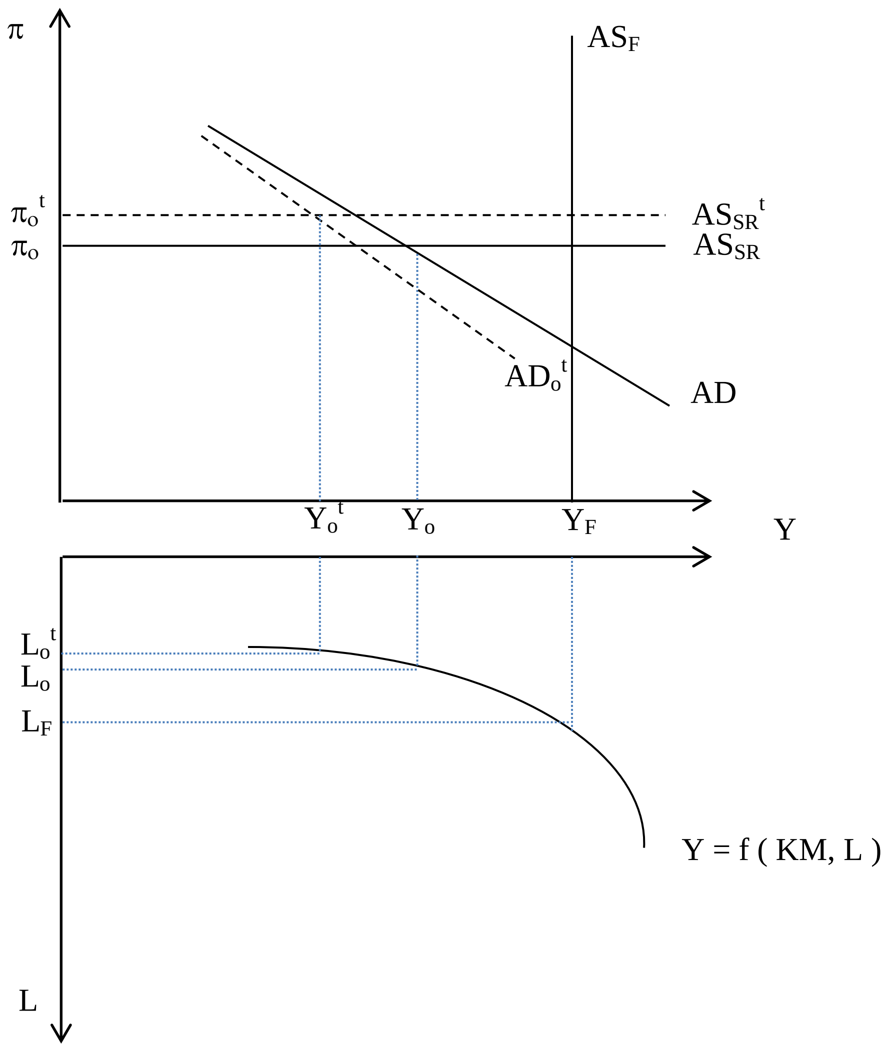

Figure 1: Standard Macroeconomic Framework

Note that $Y_F \equiv GDP \equiv \phi + \beta Y(1 - \tau)$. Assume that there is an increase in effective taxation; this will cause the AD curve to shift leftwards to AD_o^t. A resulting output gap represented by $(Y_F - Y_o)$ would be recessionary. The increase in price level, π, would be $(\pi_o^t - \pi_o)$. There would be a corresponding increase in the level of unemployment $(L_o - L_o^t)$.

As illustrated in Thampapillai and Sinden (2013), when point-estimate data is available for the components of (6) and (7) barring of course KN, it is possible to estimate the quantum of KN utilised as follows by dividing (5) by (7):

$$KN = \left[\left(\frac{1}{(1-\eta)} \right)^{\frac{1}{\theta}} - 1 \right] * KM \qquad (8)$$

Now, let us consider the revised standard macroeconomic framework with the internalization of KN.

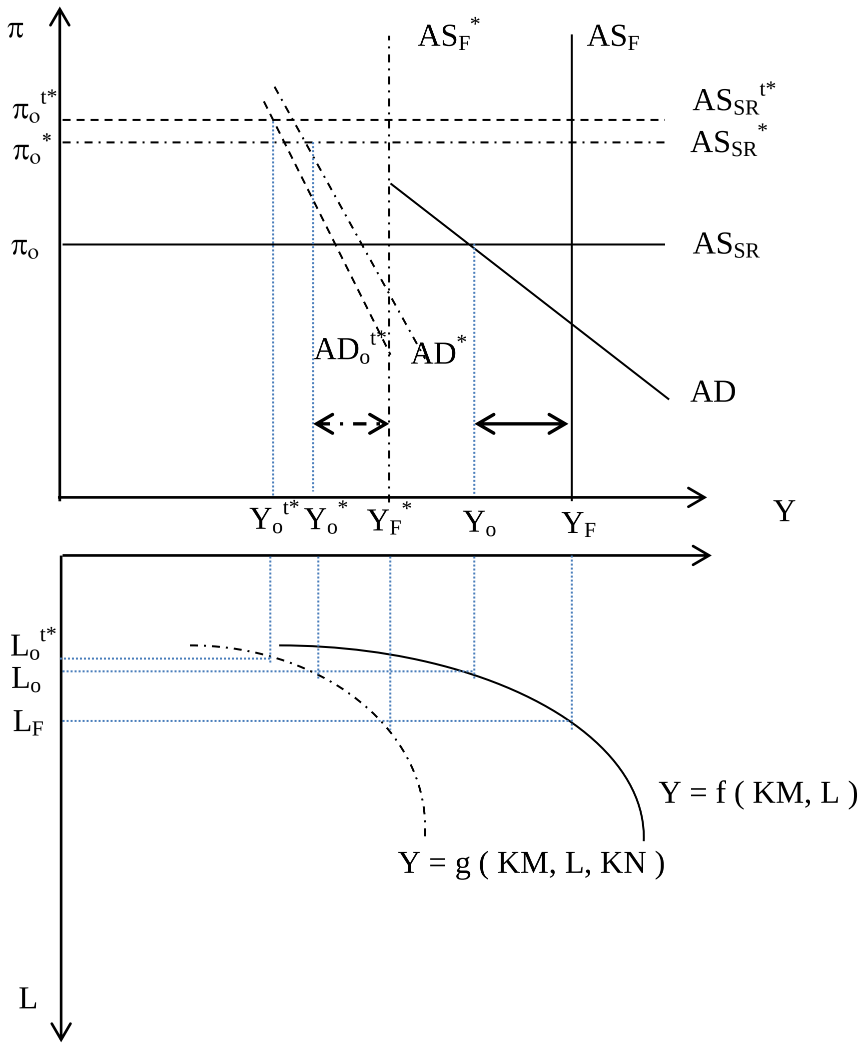

Figure 2: Environmental-Macroeconomics Framework in comparison to the Standard Macroeconomic Framework

In the environmental-macroeconomics model, GDP is now revised as per (6) to account for the depreciation of KN. The constituents of income Y now includes KM, L as well as KN (as a third factor of production in the factor utilisation function). The resulting output gap is now represented by ($Y_F^* - Y_o^*$) as opposed to ($Y_F - Y_o$) and the increase in price level, π, would be ($\pi_o^{t*} - \pi_o^*$) as opposed to ($\pi_o^t - \pi_o$) in the standard macroeconomic model. Now, assume an increase in effective taxation; this will cause the AD^* curve to shift leftwards to AD_o^{t*} in the environmental-macroeconomics model. The increase in the level of unemployment would be ($L_o - L_o^{t*}$) as opposed to ($L_o - L_o^t$) in the standard macroeconomic model.

It is apparent from Figures 1 and 2 that the changes in the level of Y, π and L will be different when the environmental-macroeconomics model is used as opposed to the standard macroeconomic model. We illustrate in Section III below the application of the two frameworks with reference to Australian data.

III. The Illustration – Environmental Taxes

We envisage the following sequence of events/outcomes with reference to our illustration on environmental taxes.

1. The introduction of a marginal tax for environmental purposes raises the effective rate of taxation.
2. Such an increase in effective taxation results in a leftward shift of AD and thereby a contraction in Y.
3. If the contraction is not remedied – for example, by returning the additional taxes as spending – then both inflation and unemployment would rise.
4. If the marginal taxes collected are returned soon enough, say, as reforestation, then apart from adding to the KN stock, there would be a reduction in D_{KN} following an appropriate lag time. We nominate this lag time as six years.

The final item listed above is not readily captured in the standard macroeconomic model as we illustrate below.

To begin with, estimate the value of Y in terms of the environmental-macroeconomics framework and illustrate that the standard macroeconomic model has overstated economic performance; Figure 3. This is of course to be expected.

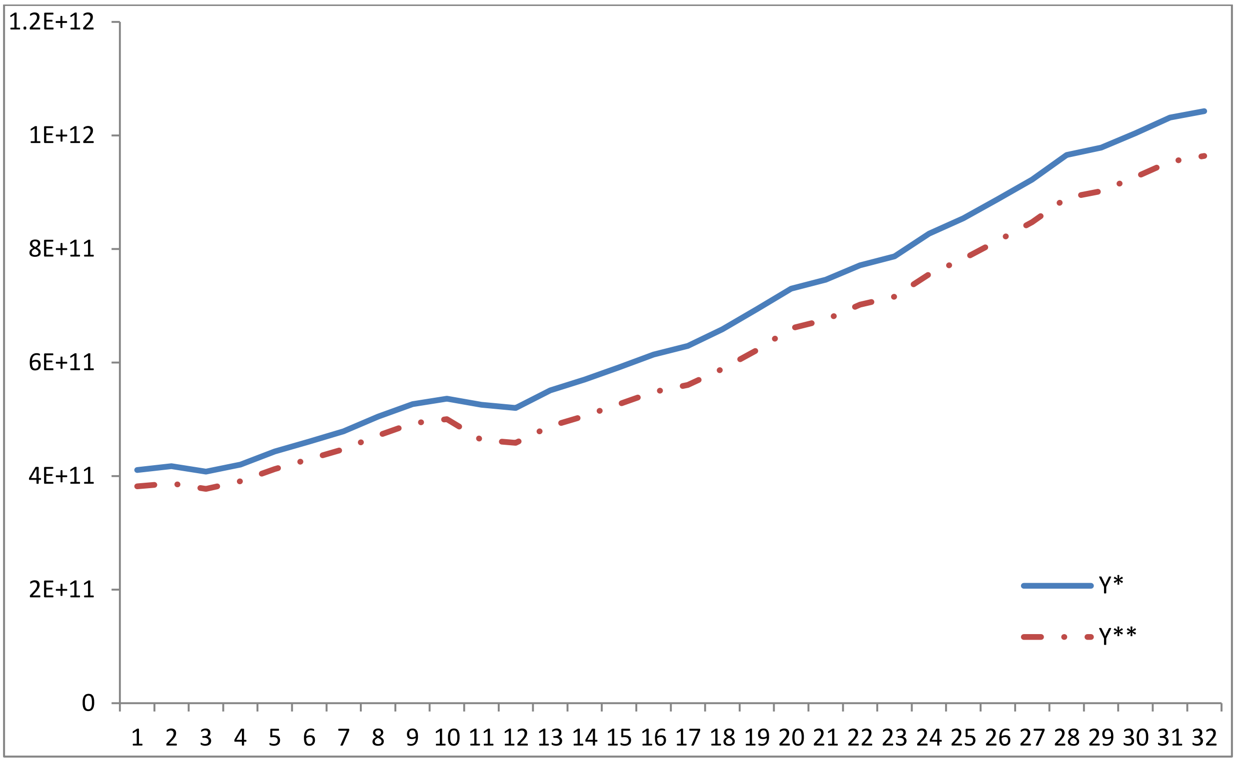

Figure 3: Comparison of the Income Paths of both Models (1980 – 2011)

Second, we also employed (8) to estimate the quantum of KN that was utilised between 1980 and 2011. KN is proxied as greenhouse gas (GHG) emissions and estimated based on the data obtained from World Development Indicators (WDI). The gases are carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), and other GHG [which includes hydrofluorocarbons (HFC), perfluorinated compounds (PFC), sulphur hexaflourinated compounds (PFC) and sulphur hexafluoride (SF_6)]. All of the GHG are converted to tons of CO_2 equivalent at a cost of USD100 / tonne – please see Stern (2007), Ackerman, et al. (2009), Hope (2011), and Karstad (2012). The resulting value is the total cost of air pollution and is the depreciation of environmental capital, D_{KN}.

As displayed in Figure 4, the utilisation of KN is an increasing function.

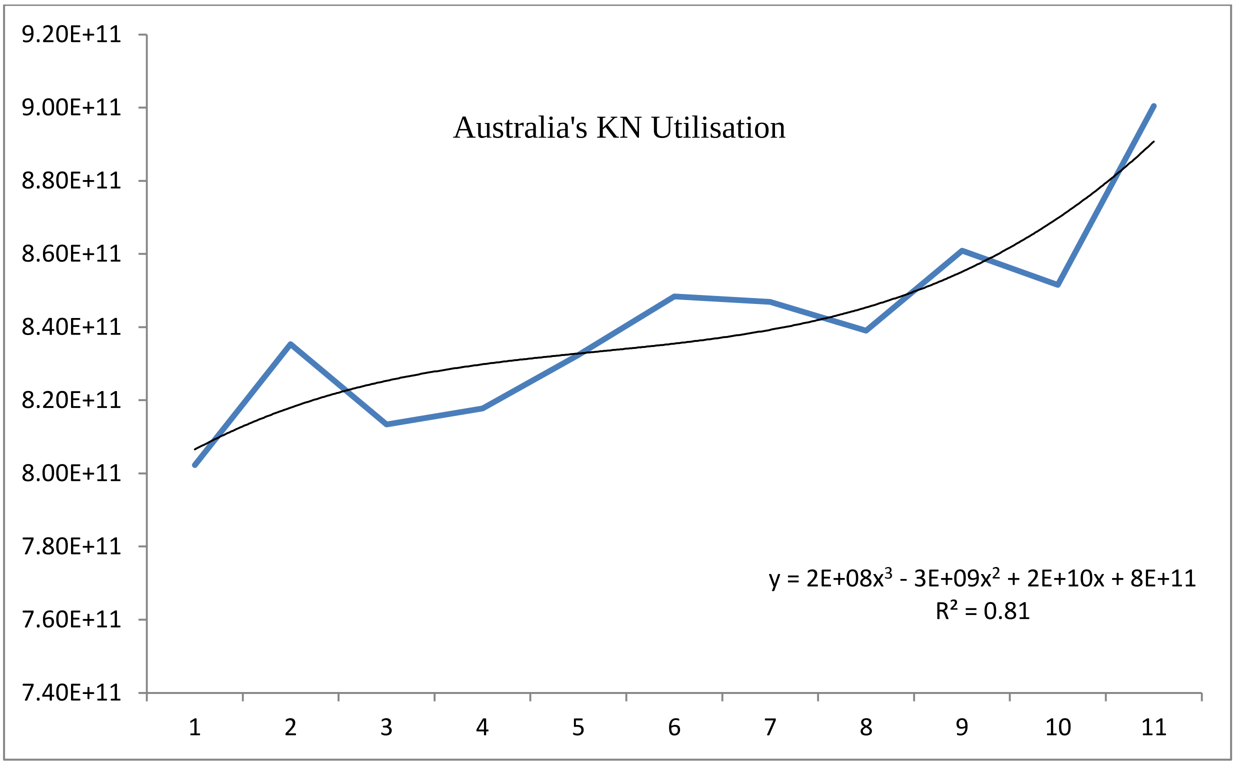

Figure 4: Australia's KN Utilisation (1990 – 2011)

Simulations

As indicated, we also simulated potential outcomes with reference to both models. For this purpose, we nominate 2011 as an initial year and use the pertinent coefficients of the two models to resolve for Y, π and L. These coefficients, together with the expectations concerning their changes until 2020 are presented in Tables 1A and 1B. The tables also include the results of the analysis with reference to the outcome variables.

The expectations concerning the coefficients are gleaned from the time series data used in this study. The data reveals that the only coefficients likely to increase in the foreseeable future are Φ, KM and L_F. Because the others show modest to marginal changes, we have set them to be constant.

The key outcomes with reference to Y, π and L are illustrated in Figures 5 – 7 below.

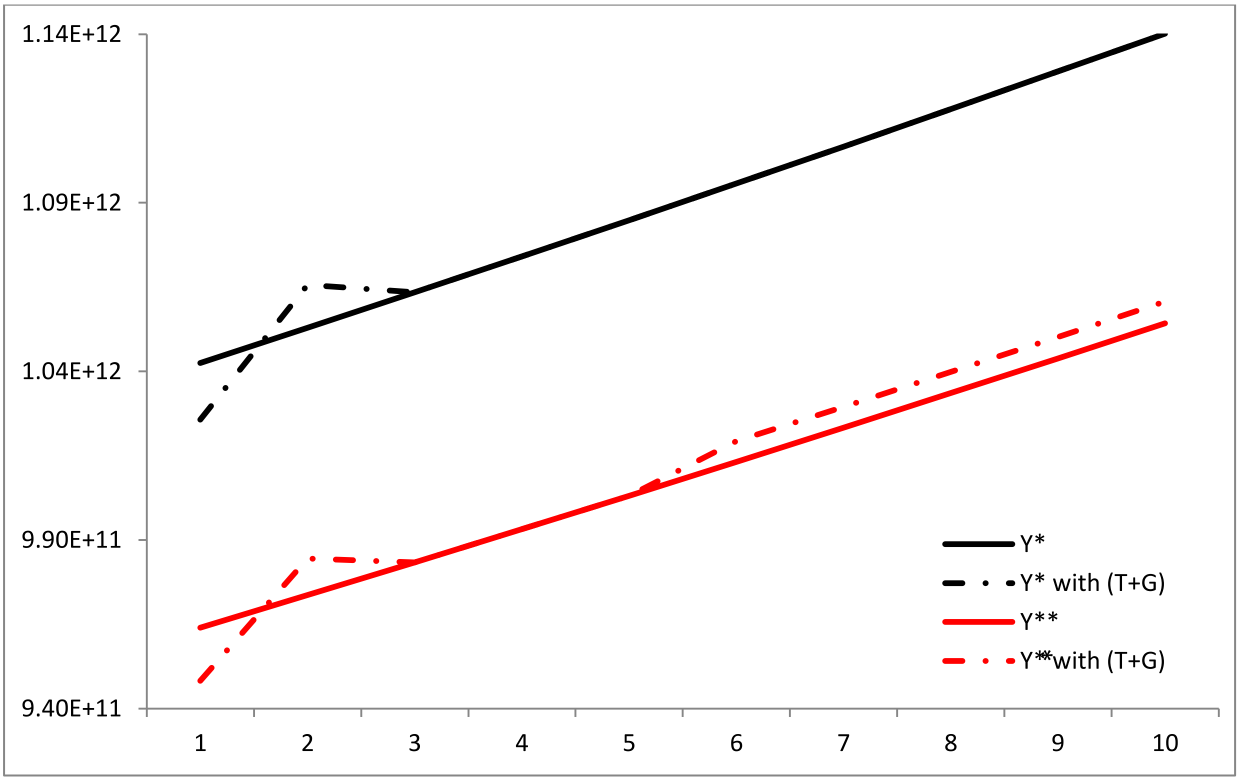

Figure 5: Simulated Income Comparisons (2011 – 2020)

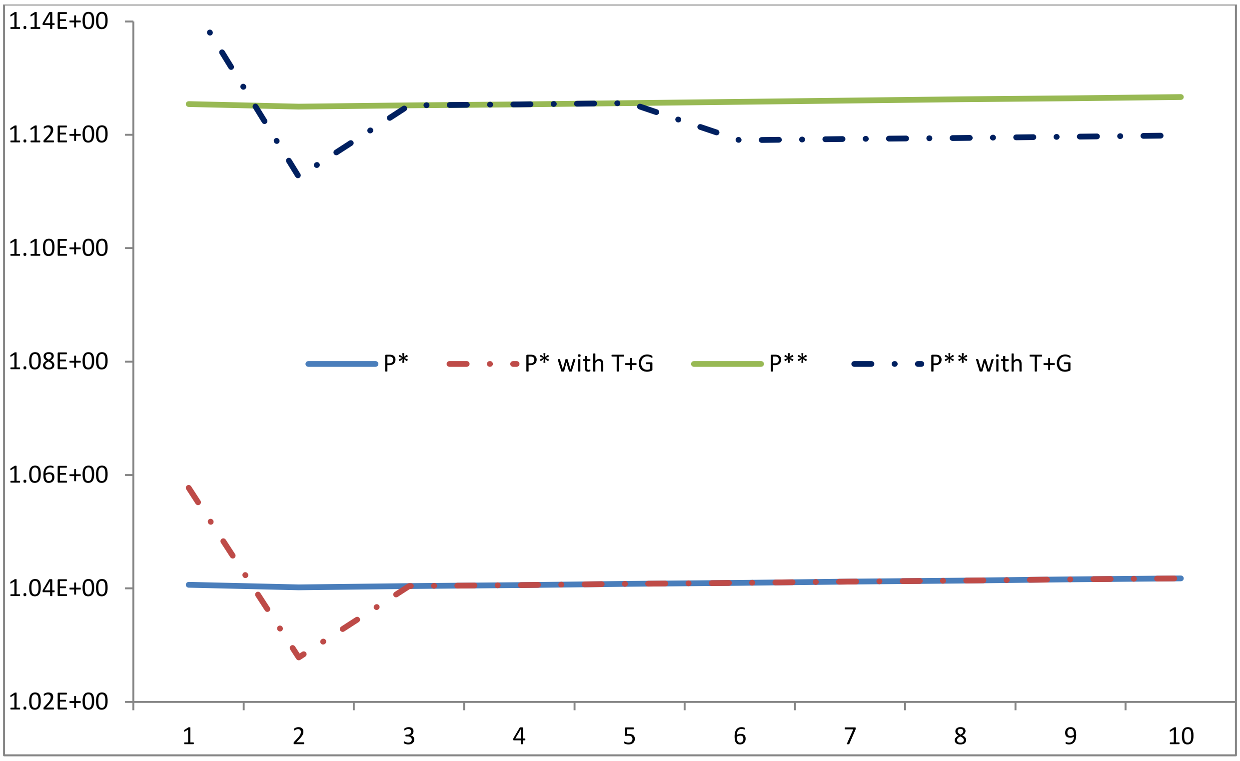

Figure 6: Simulated Inflation Paths (2011 – 2020)

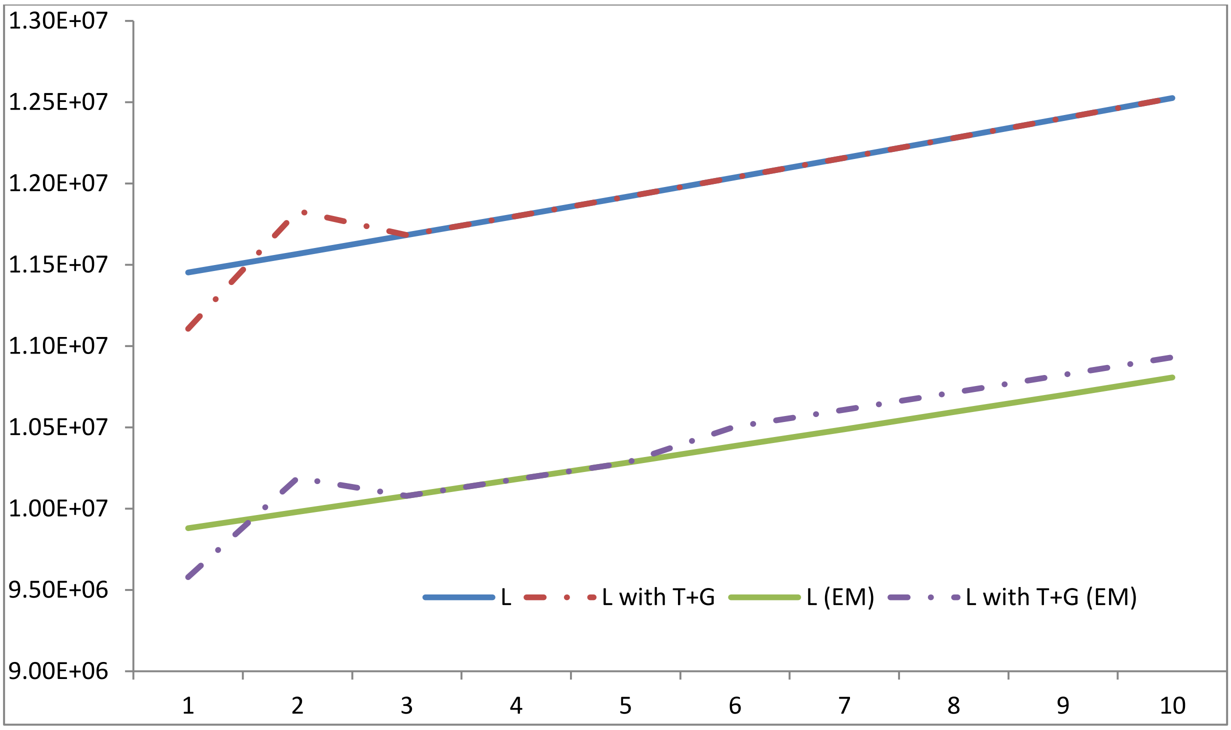

Figure 7: Employment Benefits (2011 – 2020)

The analysis rests on the introduction of a marginal tax of one per cent in 2011 – as can be seen in both model outcomes ($Y^{*}_{t2011} < Y^{*}_{2011}$) and ($Y^{**}_{t2011} < Y^{**}_{2011}$). We then assume that fifty percent of the tax revenue collected in 2011 will be returned as an environmental capital investment in 2012. The spike in {Y^{*} with T+G} and {Y^{**} with T+G} for both models represents this return. As this investment is in forestry, we suppose that the coefficient pertaining to D_{KN}, namely η would decrease by three percent after six years.

As can be observed, with the standard macroeconomic model, barring the changes in 2012 due to the return of a portion of tax revenue, the outcome variables {Y^{*}, [Y^{*} with T+G]}, {L, [L with T+G]} and {π, [π with T+G]} show no variation whatsoever. This is not the case with the results of the environmental-macroeconomics model. From both Tables 1A and 1B and Figures 5 – 7, it is clear that the enhanced sequestration capacity of KN can lead to clear benefits which are captured in the environmental-macroeconomics model. These benefits are: increased income, stabilized inflation levels and reduced unemployment.

IV. Conclusion

The revenue from taxes can cut budget deficits while meeting environmental objectives. Environmental taxes are defined as “green taxes” by Hecht (2005). “Green taxes” can be recycled to allow other forms of taxes, for example, income tax, to be reduced towards a “green income”. Collier (2010) advocates a carbon tax because it allows taxation on other economic activity to be reduced, and would be better than a heavily compromised emissions trading scheme (Garnaut, 2008).

Environmental taxation for a sustainable future requires the discipline of policy makers to carry out fiscal reforms. Fiscal consolidation and climate policy can reap sustained welfare gains for future generations (Rausch, 2013). However, such reforms are often restricted by politics and institutions

(Besley, Ilzetzki and Persson, 2013) and such taxes need to be reinvested within the confines of fiscal balance (Thampapillai, Wu and Tan, 2010).

In the case of Australia, such taxes can be reinvested into the sensitive ecosystem and agricultural technology to address food security challenges. It is obvious that there are multi-faceted considerations for each policy option and there can be a portfolio of investments where revenue from taxes can be re-invested towards. More importantly, the argument should lie in applying an environmental-macroeconomics framework which will address the macroeconomic objectives of income, inflation and employment towards a sustainable future.

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TABLE-1A:

Standard Model	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Pt	1.28	1.3312	1.384448	1.439826	1.497419	1.557316	1.619608	1.684393	1.751768	1.821839
M1	2.63E+11	2.71E+11	2.79E+11	2.88E+11	2.96E+11	3.05E+11	3.14E+11	3.24E+11	3.33E+11	3.43E+11
V	5.07E+00	5.17E+00	5.28E+00	5.38E+00	5.49E+00	5.60E+00	5.71E+00	5.82E+00	5.94E+00	6.06E+00
Pt-1	1.23E+00	1.28E+00	1.33E+00	1.38E+00	1.44E+00	1.50E+00	1.56E+00	1.62E+00	1.68E+00	1.75E+00
Φ	4.22E+11	4.26E+11	4.31E+11	4.35E+11	4.39E+11	4.44E+11	4.48E+11	4.53E+11	4.57E+11	4.62E+11
β	6.65E-01	6.65E-01	6.65E-01	6.65E-01	6.65E-01	6.65E-01	6.65E-01	6.65E-01	6.65E-01	6.65E-01
τ	1.05E-01	1.05E-01	1.05E-01	1.05E-01	1.05E-01	1.05E-01	1.05E-01	1.05E-01	1.05E-01	1.05E-01
θ	4.69E-01	4.69E-01	4.69E-01	4.69E-01	4.69E-01	4.69E-01	4.69E-01	4.69E-01	4.69E-01	4.69E-01
λ	5.31E-01	5.31E-01	5.31E-01	5.31E-01	5.31E-01	5.31E-01	5.31E-01	5.31E-01	5.31E-01	5.31E-01
α	2.06E+02	2.06E+02	2.06E+02	2.06E+02	2.06E+02	2.06E+02	2.06E+02	2.06E+02	2.06E+02	2.06E+02
LF	1.21E+07	1.23E+07	1.26E+07	1.28E+07	1.31E+07	1.33E+07	1.36E+07	1.39E+07	1.41E+07	1.44E+07
Capital Stock (KM)	4.96E+12	5.01E+12	5.06E+12	5.11E+12	5.16E+12	5.21E+12	5.26E+12	5.32E+12	5.37E+12	5.42E+12
Y*	1.04E+12	1.05E+12	1.06E+12	1.07E+12	1.08E+12	1.10E+12	1.11E+12	1.12E+12	1.13E+12	1.14E+12
Y*t	1.03E+12									
Y* with (T+G)	1.03E+12	1.07E+12	1.06E+12	1.07E+12	1.08E+12	1.10E+12	1.11E+12	1.12E+12	1.13E+12	1.14E+12
YF	1.07E+12	1.09E+12	1.10E+12	1.12E+12	1.14E+12	1.16E+12	1.17E+12	1.19E+12	1.21E+12	1.23E+12
L	1.15E+07	1.16E+07	1.17E+07	1.18E+07	1.19E+07	1.20E+07	1.22E+07	1.23E+07	1.24E+07	1.25E+07
L with T+G	1.11E+07	1.18E+07	1.17E+07	1.18E+07	1.19E+07	1.20E+07	1.22E+07	1.23E+07	1.24E+07	1.25E+07
Π∗	1.04E+00	1.04E+00	1.04E+00	1.04E+00	1.04E+00	1.04E+00	1.04E+00	1.04E+00	1.04E+00	1.04E+00
Π∗ with T+G	1.06E+00	1.03E+00	1.04E+00	1.04E+00	1.04E+00	1.04E+00	1.04E+00	1.04E+00	1.04E+00	1.04E+00
PF	1.01E+00	1.01E+00	1.00E+00	9.97E-01	9.92E-01	9.87E-01	9.82E-01	9.77E-01	9.72E-01	9.67E-01
LF-L	6.11E+05	7.38E+05	8.68E+05	1.00E+06	1.14E+06	1.28E+06	1.43E+06	1.58E+06	1.73E+06	1.89E+06
LF-L with T+G	9.57E+05	4.74E+05	8.68E+05	1.00E+06	1.14E+06	1.28E+06	1.43E+06	1.58E+06	1.73E+06	1.89E+06

TABLE-1B

EM Model	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Pt	1.28	1.3312	1.384448	1.439826	1.497419	1.557316	1.619608	1.684393	1.751768	1.821839
M1	2.63E+11	2.71E+11	2.79E+11	2.88E+11	2.96E+11	3.05E+11	3.14E+11	3.24E+11	3.33E+11	3.43E+11
V	5.07E+00	5.17E+00	5.28E+00	5.38E+00	5.49E+00	5.60E+00	5.71E+00	5.82E+00	5.94E+00	6.06E+00
Pt-1	1.23E+00	1.28E+00	1.33E+00	1.38E+00	1.44E+00	1.50E+00	1.56E+00	1.62E+00	1.68E+00	1.75E+00
Φ	4.22E+11	4.26E+11	4.31E+11	4.35E+11	4.39E+11	4.44E+11	4.48E+11	4.53E+11	4.57E+11	4.62E+11
β	7.26E-01	7.26E-01	7.26E-01	7.26E-01	7.26E-01	7.26E-01	7.26E-01	7.26E-01	7.26E-01	7.26E-01
τ	1.13E-01	1.13E-01	1.13E-01	1.13E-01	1.13E-01	1.13E-01	1.13E-01	1.13E-01	1.13E-01	1.13E-01
η	7.53E-02	7.53E-02	7.53E-02	7.53E-02	7.53E-02	7.53E-02	7.53E-02	7.53E-02	7.53E-02	7.53E-02
η revised	7.53E-02	7.53E-02	7.53E-02	7.53E-02	7.53E-02	7.31E-02	7.31E-02	7.31E-02	7.31E-02	7.31E-02
θ	4.69E-01	4.69E-01	4.69E-01	4.69E-01	4.69E-01	4.69E-01	4.69E-01	4.69E-01	4.69E-01	4.69E-01
λ	5.31E-01	5.31E-01	5.31E-01	5.31E-01	5.31E-01	5.31E-01	5.31E-01	5.31E-01	5.31E-01	5.31E-01
α	2.06E+02	2.06E+02	2.06E+02	2.06E+02	2.06E+02	2.06E+02	2.06E+02	2.06E+02	2.06E+02	2.06E+02
LF	1.21E+07	1.23E+07	1.26E+07	1.28E+07	1.31E+07	1.33E+07	1.36E+07	1.39E+07	1.41E+07	1.44E+07
Capital Stock (KM)	4.96E+12	5.01E+12	5.06E+12	5.11E+12	5.16E+12	5.21E+12	5.26E+12	5.32E+12	5.37E+12	5.42E+12
KN Utilized	9.00E+11	9.09E+11	9.19E+11	9.28E+11	9.37E+11	9.46E+11	9.56E+11	9.65E+11	9.75E+11	9.85E+11
Y**	9.64E+11	9.74E+11	9.83E+11	9.93E+11	1.00E+12	1.01E+12	1.02E+12	1.03E+12	1.04E+12	1.05E+12
Y*t	9.48E+11									
Y* with (T+G)	9.48E+11	9.84E+11	9.83E+11	9.93E+11	1.00E+12	1.02E+12	1.03E+12	1.04E+12	1.05E+12	1.06E+12
YF	9.91E+11	1.01E+12	1.02E+12	1.04E+12	1.05E+12	1.07E+12	1.09E+12	1.10E+12	1.12E+12	1.14E+12
L (EM)	9.88E+06	9.98E+06	1.01E+07	1.02E+07	1.03E+07	1.04E+07	1.05E+07	1.06E+07	1.07E+07	1.08E+07
L with T+G (EM)	9.58E+06	1.02E+07	1.01E+07	1.02E+07	1.03E+07	1.05E+07	1.06E+07	1.07E+07	1.08E+07	1.09E+07
Π**	1.13E+00	1.12E+00	1.13E+00	1.13E+00	1.13E+00	1.13E+00	1.13E+00	1.13E+00	1.13E+00	1.13E+00
Π** with T+G	1.14E+00	1.11E+00	1.13E+00	1.13E+00	1.13E+00	1.12E+00	1.12E+00	1.12E+00	1.12E+00	1.12E+00
PF	1.09E+00	1.09E+00	1.08E+00	1.08E+00	1.07E+00	1.06E+00	1.06E+00	1.05E+00	1.05E+00	1.04E+00
LF-L	2.18E+06	2.33E+06	2.47E+06	2.62E+06	2.78E+06	2.93E+06	3.10E+06	3.26E+06	3.43E+06	3.61E+06
LF-L with T+G	2484036	2115079	2471490	2621713	2775947	2815435	2976779	3142400	3312394	3486860