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Macroeconomics versus environmental-macroeconomics*

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When environmental macroeconomic frameworks replace standard macroeconomic frameworks differences in policy outcomes ensue. The non-recognition of real environmental capacity constraints could explain the inability of standard frameworks to deliver on certain macroeconomic goals. Herein, environmental capital depreciation is internalised into analytic frameworks of factor utilisation, aggregate demand and aggregate supply. The analyses reveal that restricted income and wage domains alongside limited environmental capacity constrain economic performance. Hence, environmental capacity expansion and initiatives towards sustainability warrant specific attention. Illustrations are made with reference to the Australian economy and her response to the 2008–2010 global financial crisis.

Key words: environmental capital, environmental macroeconomics, macroeconomics.

1. Introduction

Extensive reviews of the theory and analysis of environmental economics, (for example, Cropper and Oates 1992 and Stavins 2004) have the domain firmly fixed on microeconomics. Nevertheless, the tradition of environmental capital (KN) in macroeconomics dates back to Marshall (1890) who exposited KN as ultimate capital – because the ultimate components of all items stem from nature. Capital theory (Fisher 1904) itself owes its origins to the acknowledged premise of KN being a stock that generates a flow.

The main object of this study is to demonstrate the significant differences that would emerge in policy formulation when environmental macroeconomic frameworks are employed in lieu of the standard frameworks. Towards this end, the method employed here is an ex-post analysis and involves the display of a sequence of snapshots of the economy. Each snapshot is a macroeconomic representation of the economy and this in turn is a manifest of the underlying framework employed. More often than not, a given snapshot is likely to reveal the presence of disequilibria owing to the presence of gaps in employment, output and inflation. Hence, a snapshot facilitates the choice of decisions that could help to close the gaps and

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converge towards some equilibrium. The main contention herein is that the utilisation of the environmental macroeconomic framework could lead to income and employment outcomes that are more sustainable than those elicited from standard frameworks.

This article is structured as follows. The next section deals with an explanation of the analytic frameworks for both the standard and the environmental macroeconomic contexts. This is followed by an empirical illustration with reference to Australia. The Australian response to the global financial crisis (GFC) over the period 2008–2010 is employed to illustrate the variations in policy directives that would arise when the different types of frameworks are employed.

2. The analytic framework

The display of snapshots is enabled by fitting point estimate data of relevant time periods to assumed functional forms that describe the macroeconomic frameworks. That is, specific functional forms are deemed valid descriptors of the frameworks chosen. The standard representation considered here comprises the joint display of: aggregate demand (AD), aggregate supply (AS) and factor utilisation. In the environmental macroeconomic representation, the above frameworks are revised for recognising KN. The descriptions of the standard and environmental macroeconomic frameworks are next considered in turn.

2.1. The standard macroeconomic framework

Some simplifying assumptions are made with reference to the description of the component frameworks to facilitate the use of point estimate data. The factor utilisation framework is assumed to be a Cobb-Douglas (C-D) function of constant returns to scale involving two factors, namely manufactured capital stock (KM) and labour (L):

$$Y_t = \alpha_t \, \mathrm{KM}_t^{\theta_t} \, L_t^{\lambda_t} \tag{1}$$

where θ_t and λ_t, represent the factor shares of national income (Y_t) in time t accruing, respectively, to KM and L; and owing to the assumption of constant returns to scale, ($\theta_t + \lambda_t = 1$).

The assumption of constant returns to scale enables factor shares of income to be elicited directly from the income accounts where the following identity prevails:

$$Y_t \equiv \text{Compensation to Employees (CEt)} + \text{Operating Surplus (OSt)} \tag{2}$$

Because CE and OS represent, respectively, payments accruing to L and KM,

$$\lambda_t = \frac{\mathrm{CE}_t}{Y_t}; \theta_t = \frac{\mathrm{OS}_t}{Y_t} \quad (3)$$

Given the point estimate data on KM_t and L_t, the estimation of the total factor productivity measure, namely α_t is feasible. This C-D function can then enable the identification of capacity (full employment) income ($Y_{\mathrm{F}t}$) and the output gap ($Y_{\mathrm{F}t} - \mathrm{Y}_t$) in terms of employment (L_t) and the labour force ($L_{\mathrm{F}t}$).

The exposition of *AS* is simplified by differentiating capacity supply (AS_F) from a short-run response ($\mathrm{AS}_{\mathrm{SR}}$). The latter is assumed to be Keynesian. That is, producers expect prevailing prices π_t (inflation rate) to persist in the short run and hence will strive to produce as much as possible ($Y \to \infty$) at these prices:

$$\mathrm{AS}_{\mathrm{SR}}t : \{ (\pi = \pi_t) \,|\, (Y \to \infty)\} \quad (4)$$

Given that capacity ($Y_{\mathrm{F}t}$) in a given time period (t) cannot be exceeded, $\mathrm{AS}_{\mathrm{F}t}$ is defined as:

$$\mathrm{AS}_{\mathrm{F}t}\{(Y = Y_{\mathrm{F}t}) \,|\, (\pi \to \infty)\} \quad (5)$$

A simple exposition of AD following Mankiw (2010) and Flath (2005) is premised on the Quantity Equation, that is:

$$\pi_{\mathrm{t}} = \left[\frac{M_t\,V_t}{Y_t\,P_{t-1}}\right] \quad (6)$$

where (P_{t-1}, M_t, V_t) represent, respectively, the price level of the previous period; and money stock and velocity in t.

In (6) the rate of (π) is scaled such that ($\pi = 1$) represents stationary price level; that is $[P_t = \pi_{\mathrm{t}}\,P_{\mathrm{t-1}}]$.

The display of a given snapshot and the elicitation of likely changes due to possible methods of intervention are further aided by the following set of simplifying assumptions:

1. Given π_t and Y_t in time t, a short-run equilibrium namely $\{\mathrm{AS}_{\mathrm{SR}t} = \mathrm{AD}_t\}$ does exist for (Y_t, π_t).
2. The definition of money stock is confined to narrow money (M1). The changes in M1 in response to changes in the interest rate (Δr) are given by $\left(\frac{\mathrm{d}M}{\mathrm{d}r}\right)$, which as indicated below is based on time trends of M and r.
3. Expected changes in expenditure in a given time t, (GDP_t), are drawn from changes in the following: tax rates ($\Delta\tau$) influencing consumption (C), government spending (ΔG); and interest rates (Δr) influencing investment stock (I).

4. Velocity of money during a given time period remains fixed at $\overline{V}_t$

Given the above assumptions, the following definitions can be made and then elicited from the point-estimate data of relevant time periods. These definitions enable the display of expected outcomes when likely interventions are made in terms of $\Delta\tau$, ΔG and Δr.

$$M_t = \left[M_{t-1} * \left(\left(\frac{dM}{dt} \right) + \left[\left(\frac{dM}{dr} \right) * (\Delta r_{t-1}) \right] \right) \right] \tag{7}$$

where $(\Delta r_{t-1} = r_{t-1} - r_{t-2})$ is based on the appropriate point-estimates for the interest rates and $\left(\frac{\mathrm{d}M}{\mathrm{d}r} \right) = \left(\frac{\mathrm{d}M/\mathrm{d}t}{\mathrm{d}r/\mathrm{d}t} \right)$

$$\mathrm{GDP_t} = \Phi_t + \beta_t Y_t (1 - \Delta\tau_t) + G_t + I_t, \tag{8}$$

where Φ_t, and β_t are respectively a constant comprising of net exports and marginal propensity to consume.

$$I_t = \left[I_{t-1} * \left(\left(\frac{dI}{dt} \right) + \left[\left(\frac{dI}{dr} \right) * (\Delta r_{t-1}) \right] \right) \right] \tag{9}$$

The assumption of a short-run equilibrium implies that for a given π_t, $(\mathrm{GDP}_t = Y_t)$, and hence from the foregoing an expression for AD in time t could be provided as follows:

$$\pi_t = \left[\frac{M_t \overline{V}_t}{[\Phi_t + \beta_t Y_t (1 - \tau_t) + G_t + I_t] P_{t-1}} \right] \tag{10}$$

The depiction of the snapshot will follow the display of (1), (4), (5) and (10) from the relevant point estimate data. The expected changes in the snapshot for the subsequent period will in part be determined by the responsiveness of AD to the intervention measures. For example, the responsiveness to changes in τ could be explained as:

$$\frac{\partial\pi}{\partial\tau} = \left[\frac{M_t \overline{V}_t \beta_t Y_t}{[\Phi_t + \beta_t Y_t (1 - \tau_t) + G_t + I_t]^2 P_{t-1}} \right] \tag{11}$$

The important distinction between the standard framework and the environmental macroeconomic framework is captured in terms of at least two aspects. The first is the policy domain. That is, the income domain within which the policy maker will try to resolve for inflation and employment. As illustrated in Figure 1, this domain for the standard framework is defined by $(Y_t \leftrightarrow Y_{\mathrm{F}t})$. The second aspect is the responsiveness to intervention such as that exposited in (11).

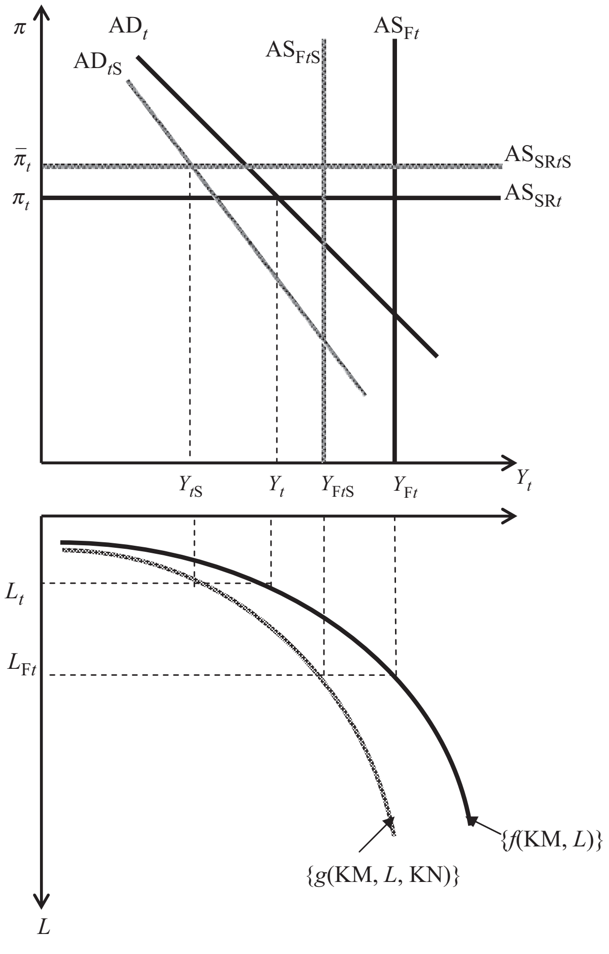

Figure 1 The standard and environmental macroeconomic frameworks – conceptual basis.

As illustrated below, both these aspects will display variations within the environmental macroeconomic framework.

2.2. The environmental macroeconomic framework

The same way as the system of national income accounting provides the basis for standard macroeconomic analysis, the analytics of environmental macroeconomics rests on the principles of environmental accounting. The definition of sustainable income (Y_S) in environmental macroeconomics can be regarded as an extension of the 'permanent income' concept advanced by Hotelling (1925) and Keynes (1936). As per this extension, national income can be sustainable if: (i) there is no diminution in the stock of KN; and (ii) the depreciation of KN, namely D_{KN}, is less than the rent generated by KN; (Thampapillai and Uhlin 1997).

A steady state, then, is a context when the stock of KN endowment is maintained and positive rents net of depreciation are earned. Hence, Y_S can be regarded as the economic rent earned from KN. This interpretation of rent is consistent with Marshall (1920): 'The labour and capital of the country acting on its *natural resources*, produce annually a certain *net aggregate of commodities….*' (Italics mine). Thus, the basic equilibrium in environmental accounting would be ($Y_{\mathrm{S}} \equiv \mathrm{GDP} - D_{\mathrm{KN}}$).

To illustrate the environmental macroeconomic framework, suppose that KN and D_{KN} can be measured on the same scale as for KM in the national accounts. When KN is introduced in the description of factor utilisation, (1) would be re-written as:

$$Y_{t\mathrm{S}} = \bar{\alpha}_{\mathrm{t}}\,\mathrm{KM}^{\bar{\theta}_t}\,L^{\bar{\lambda}_t}\,\mathrm{KN}^{\eta_t} \tag{12}$$

In (12), which is deemed, herein, as the valid descriptor for factor utilisation, η_t is the share of Y that accrues to KN in time t. Because D_{KN} represents the aggregate of compensatory payments to maintain the flow of services from KN, it can be regarded as a proxy for the KN-factor income and hence:

$$\eta_t = \frac{D_{\mathrm{KNt}}}{Y_t} \tag{13}$$

The distribution of Y between three factors, as per (12), instead of two factors as per (1), implies that $(\bar{\theta}_{\mathrm{t}} < \theta_{\mathrm{t}})and(\bar{\lambda}_t < \lambda_t)$. The retention of constant returns to scale in (12) further implies that $(\bar{\theta}_t + \bar{\lambda}_t + \eta_t = 1)$.

Further, if (12) is deemed the valid descriptor for the distribution of Y_t, it is plausible to conclude that θ_t and λ_t in (1) are over-estimates for the factor shares of Y_t because they also include the income share that should accrue to KN, namely $D_{\mathrm{KN}t}$. To estimate the values $(\bar{\theta}_t, \bar{\lambda}_t)$ assume that the remainder of Y_t after accounting for $D_{\mathrm{KN}t}$, that is, the amount ($Y_t - \mathrm{D}_{\mathrm{KN}t}$) is distributed between KM_t and L_t in the proportion defined by the ratio of their shadow prices ($P_{\mathrm{KM}t}$ and $P_{\mathrm{L}t}$). This is illustrated in (14) and (15) below. The reason for using this ratio is that the emergence of $D_{\mathrm{KN}t}$ as a cost could at least in part be due to the distortions in the markets for KM and L. Hence the coefficients $(\bar{\theta}_{\mathrm{t}}, \bar{\lambda}_{\mathrm{t}})$ in (eqn 12) can be defined as follows:

$$\bar{\theta}_t = \left(\frac{\mathrm{OS}_t - \left[\frac{P_{\mathrm{KM}}t}{P_{\mathrm{KM}t} + P_{\mathrm{L}t}}\right] * D_{\mathrm{KN}}}{Y_t}\right) \tag{14}$$

$$\bar{\lambda}_{\mathrm{t}} = \left(\frac{\mathrm{CE}_t - \left[\frac{P_{\mathrm{L}t}}{P_{\mathrm{KM}t} + P_{\mathrm{Lt}}}\right] * D_{\mathrm{KN}}}{\mathrm{Y}_t}\right) \tag{15}$$

The recognition of the revised equilibrium ($Y_S \equiv \mathrm{GDP} - D_{\mathrm{KN}}$) requires that the total factor productivity coefficient of KM and L as defined in (1) be reduced by a proportion of η_t such that when comparing (12) and (1) above, $[\bar{\alpha}_t = (1 - \eta_t)\,\alpha_t]$. Hence (12) could be restated as:

$$Y_{tS} = (1 - \eta_t)\,\alpha_t\,KM^{\bar{\theta}_t}\,L^{\bar{\lambda}_t}\,KN^{\eta_t} \tag{16}$$

Because point-estimate values of all coefficients and variables of (1) and (16) are known through either estimation or reported data, the value of KN for each year can be simply estimated through dividing (1) by (16) as in Thampapillai (2007). Hence, KN would be defined as:

$$KN_t = KM_t^{\left(\frac{\theta_t - \bar{\theta}_t}{\eta_t}\right)}\,L_t^{\left(\frac{\lambda_t - \bar{\lambda}_t}{\eta_t}\right)} \tag{17}$$

When all arguments in (16) are known, it is possible to revise the values of observed and capacity income (Y_t, and Y_{Ft}) towards values that recognise the role of KN. These are identified in Figure 1 as Y_{tS} and Y_{FtS}. Hence, capacity AS would be redefined as:

$$AS_{FtS}\{(Y = Y_{FtS})\,|\,(\pi \to \infty)\} \tag{18}$$

Note that AD_{tS} represents the revised description of AD in the context of recognising KN. Following Thamapillai and Uhlin (1997), D_{KN} is internalised into AD by redefining aggregate expenditure in (8) as:

$$GDP_t = (1 - \eta_t)\,[\Phi_t + \beta_t Y_t\,(1 - \tau_t) + G_t + I_t] \tag{19}$$

Hence, the revised definitions for AD:

$$\pi_t = \left[\frac{M_t \overline{V}_t}{(1 - \eta_t)\,[\Phi_t + \beta_t Y_t\,(1 - \tau_t) + G_t + I_t]\,P_{t-1}}\right] \tag{20}$$

The short-run supply response is also revised as:

$$AS_{SRtS}\{(\pi = \overline{\pi}_t)\,|\,(Y \to \infty)\} \tag{21}$$

The size of $\overline{\pi}_t$ in (21) is likely to be higher than π_t in (4) owing to the internalisation of KN in (20). The coordinates of the short-run equilibrium for $\{AS_{SRt} = AD_{tS}\}$ is revised as $(Y_t S, \overline{\pi}_t)$.

The depiction of the snapshot will follow the display of (16), (18), (19) and (21) from the relevant point estimate data. As with the standard framework, the expected changes in the snapshot for the subsequent period will be in part determined by the responsiveness to intervention measures. The counterpart of (11) above in the revised context would be:

$$\frac{\partial \pi}{\partial \tau} = \left[\frac{M_t \overline{V}_t \beta_t Y_t}{[\Phi_t + \beta_t Y_t\,(1 - \tau_t) + G_t + I_t]^2\,(1 - \eta_t) P_{t-1}}\right] \tag{22}$$

A comparison of (11) and (22) reveals that the inflationary response to changes in τ would be higher in the context of the environmental macroeconomic framework than the standard framework. This is verified in the following sections. The two types of frameworks described above are illustrated in Figure 1.

3. The illustration

As indicated, in this ex-post analysis, two types of snapshots, namely *expected* and *actual* snapshots, are generated following the initial snapshot for each type of framework. Policy intervention is confined to monetary and fiscal measures. As indicated below, these interventions can be ascertained from the national accounts and the minutes of the Reserve Bank of Australia (RBA) that are accessible on the public domain. The display of snapshots commences with the last quarter of 2007 because vastly different types of intervention measures were adopted subsequent to this period owing to the GFC. The final period for the display is 2010-Q2.

It is assumed that the development of the expected snapshot for a subsequent time period, say $(t + 1)$, would follow a sequence of steps as outlined below:

1. Identification of the state of the economy in terms of output, employment and inflation gaps.
2. Estimation of output response (Y_{t+1}) to fiscal and monetary intervention measures by recourse to application of definitions of GDP – (8) and (19) above.
3. Estimation of employment (L_{t+1}) that corresponds to (Y_{t+1}) by recourse to the application of the factor utilisation functions – (1) and (16).
4. The estimation of the full employment level $(L_{\mathrm{F}t+1})$ by recourse to the trend in labour force growth and the value of capacity income (Y_{Ft+1}) by recourse to factor utilisation functions – (1) and (16). This would enable the display of capacity AS_{Ft+1}.
5. Estimation of (π_{t+1}) and (π_{Ft+1}) that correspond to (Y_{t+1}) and (Y_{Ft+1}) by recourse to the application of AD functions – (10) and (21).
6. Display of output, employment and inflation gaps for $(t + 1)$.

Within the above sequence, in the absence of any policy intervention, the exposition of the expected snapshot is guided by the estimation of $(\mathrm{d}/\mathrm{d}t)$ for pertinent variables and coefficients, for example, consider (7) above. In the absence of any monetary policy intervention, the change in M_t is assumed to be guided solely by $(\mathrm{d}M/\mathrm{d}t)$. The $(\mathrm{d}/\mathrm{d}t)$ values estimated for the analysis are summarised in Table A1 in the appendix. Pertinent quarterly data for the period 2001-Q1 to 2010 Q-2 were drawn from the OECD e-library. Figure A2 in the appendix presents an overview of the basis for generating expected values.

For the illustration of the environmental macroeconomic framework, D_{KN} is confined to the cost of CO_2 pollution abatement. CO_2 emission data were drawn from the World Development Indicators for Australia and an emission expenditure of USD 100/tonne was used as per Stern (2006). Further, the estimation of $(\overline{\theta}_t, \overline{\lambda}_t)$in the environmental macroeconomic framework requires the estimation of shadow prices for KM and L. Following the standard traditions of cost-benefit analysis, P_{KMt} is approximated to the long-term government bond rate. P_{Lt} is estimated as a capital equivalent price of L. For this purpose, CE is adjusted downwards to reflect the prevailing rate of unemployment. To obtain this adjusted value, CE_{St}, first an average wage rate that would support full employment in period t, W_{St}, is estimated : for example, through dividing CE by the labour force. CE_{St} is then defined as (W_{St} * L_t), where L_t is the actual workforce. P_{Lt} as a capital equivalent price would then equal (CE_{St}/KM_t). Because intervention is limited to monetary and fiscal measures, the anticipated changes are captured by recourse to changes in (10), (11), (20) and (22). The policy intervention measures that were adopted in terms of interest rates (r), taxation rate (τ) and government spending (G) are summarised in Table 1.

The observed and expected values with reference to inflation, output and employment are summarised in Table 2 below. These three categories are considered in turn below.

3.1. Inflation

Consider first the observation with reference to π_t (Figure 2 and Table 2a). Both the expected and observed values of inflation elicited from the environmental macroeconomic framework are consistently higher than those from the standard framework. This is to be expected given the smaller denominator in (20) compared with that in (10). Note, though, that the observed value of inflation with reference to the standard framework coincides with the reported value of inflation.

During the period Q4-2007 to Q2-2008, the RBA felt compelled to raise interest rates. As per the minutes of a board meeting (Reserve Bank of Australia 2008), there were expressed concerns with inflationary forces and pres-

Table 1 Monetary and fiscal intervention Q4-2007 to Q2-2010

	Δr	G	τ
Q4-2007	0.25	39.02	0.12
Q1-2008	0.47	39.49	0.12
Q2-2008	0.03	40.44	0.11
Q3-2008	−0.23	40.83	0.11
Q4-2008	−2.67	41.53	0.11
Q1-2009	−1.10	41.76	0.11
Q2-2009	−0.25	42.05	0.11
Q3-2009	0.00	42.92	0.11
Q4-2009	0.74	43.67	0.11
Q1-2010	0.24	44.37	0.11
Q2-2010	0.52	45.17	0.11

Table 2 Observed and expected outcomes – (a) inflation (b) income (c) employment and labour force

	π_t (%)				π_{Ft} (%)			
	SFW		EMFW		SFW		EMFW	
Period	Observed	Expected	Observed	Expected	Observed	Expected	Observed	Expected
(a)								
Q4-2007	1.007	1.007	1.175	1.175	0.908	0.904	1.071	1.071
Q1-2008	1.010	1.011	1.174	1.178	0.912	0.904	1.074	0.919
Q2-2008	1.002	1.014	1.155	1.181	0.911	0.903	1.055	0.922
Q3-2008	1.004	0.999	1.149	1.162	0.913	0.904	1.052	0.909
Q4-2008	0.993	0.993	1.140	1.153	0.910	0.901	1.042	0.904
Q1-2009	1.007	0.961	1.163	1.112	0.905	0.895	1.058	0.876
Q2-2009	1.005	0.927	1.176	1.069	0.903	0.866	1.066	0.845
Q3-2009	1.003	0.914	1.172	1.053	0.903	0.852	1.062	0.834
Q4-2009	1.010	0.911	1.180	1.049	0.905	0.846	1.071	0.832
Q1-2010	1.007	0.916	1.170	1.054	0.908	0.843	1.066	0.837
Q2-2010	1.012	0.922	1.167	1.060	0.908	0.846	1.063	0.843
	Y_t (Year 2000 $billion)				Y_{Ft} (Year 2000 $billion)			
	SFW		EMFW		SFW		EMFW	
Period	Observed	Expected	Observed	Expected	Observed	Expected	Observed	Expected
(b)								
Q4-2007	204.09	204.09	174.87	174.87	224.66	224.66	191.86	191.86
Q1-2008	207.21	205.63	178.25	176.36	227.14	227.25	194.77	226.21
Q2-2008	213.34	207.19	185.14	177.82	234.20	229.88	202.61	227.78
Q3-2008	219.47	212.86	191.76	182.93	240.44	232.56	209.41	233.87
Q4-2008	220.00	216.00	191.53	185.92	241.71	235.29	209.64	237.16
Q1-2009	217.32	224.33	188.12	194.02	240.09	238.07	206.95	246.14
Q2-2009	212.17	227.67	181.40	197.42	234.97	240.89	200.11	249.64
Q3-2009	214.13	229.91	183.25	199.65	237.21	243.77	202.24	251.95
Q4-2009	215.91	231.89	184.95	201.59	238.69	246.70	203.72	253.95
Q1-2010	219.97	232.60	189.31	202.25	242.14	249.69	207.67	254.56
Q2-2010	226.07	234.69	196.02	204.23	249.01	252.72	215.17	256.68
	L_t (Million persons)				L_{Ft} (Million persons)			
	SFW		EMFW		SFW		EMFW	
Period	Observed	Expected	Observed	Expected	Observed	Expected	Observed	Expected
(c)								
Q4-2007	9.43	9.43	9.43	9.43	11.25	11.25	11.25	11.25
Q1-2008	9.55	9.49	9.55	9.49	11.31	11.31	11.31	11.31
Q2-2008	9.58	9.55	9.58	9.55	11.39	11.37	11.39	11.37
Q3-2008	9.65	9.61	9.65	9.61	11.45	11.43	11.45	11.43
Q4-2008	9.67	9.67	9.67	9.67	11.50	11.49	11.50	11.49
Q1-2009	9.64	9.73	9.64	9.73	11.59	11.56	11.59	11.56
Q2-2009	9.66	9.79	9.66	9.79	11.64	11.62	11.64	11.62
Q3-2009	9.67	9.85	9.67	9.85	11.67	11.68	11.67	11.68
Q4-2009	9.73	9.91	9.73	9.91	11.73	11.74	11.73	11.74

Table 2 (*Continued*)

	L_t (Million persons)				L_{Ft} (Million persons)			
	SFW		EMFW		SFW		EMFW	
Period	Observed	Expected	Observed	Expected	Observed	Expected	Observed	Expected
Q1-2010	9.85	9.98	9.85	9.98	11.80	11.81	11.80	11.81
Q2-2010	9.87	10.04	9.87	10.04	11.86	11.87	11.86	11.87

SFW, standard framework; EMFW, environmental macroeconomic framework.

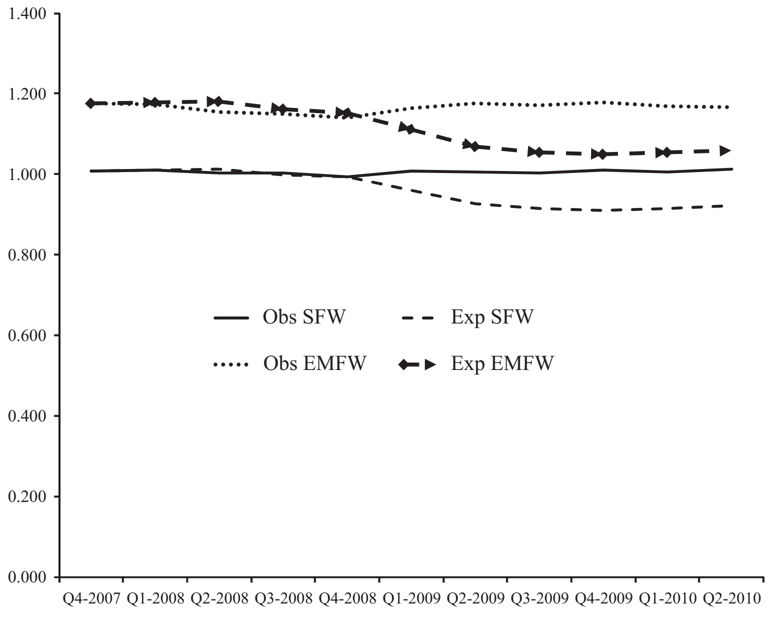

Figure 2 Observed versus expected inflation levels (Q4-2007 to Q2-2010).

sures on productive capacity. Hence the RBA intervened by raising interest rates. Such intervention was dramatically reversed from the third quarter of 2008. Nevertheless, the reported values of inflation remained steady despite the RBA's varying intervention (tightening as well as loosening). The presence of environmental capacity constraints is a likely cause for the unresponsiveness of inflation to the interventions as discussed below. It is further noteworthy that the expected level of inflation generated by the environmental macroeconomic framework gets closer to the reported value of inflation during the stimulus period.

A comparison of the snapshots for Q4-2007 derived from the standard and environmental macroeconomic frameworks quite clearly shows the presence of an environmental capacity constraint that was not recognised. As such, the rate increases during the earlier parts of the study period might have been unwarranted. Instead various efforts to enhance environmental capital capacity might have been in order. The case for this argument is illustrated in Figure 3.

Note that the observed level of Y in the standard framework ($Y_{\text{Q4-07}}$ = \$204.09 billion) exceeds the capacity level of Y in the environmental macroeconomic framework, namely ($Y_{\text{FSQ4-07}}$ = \$191.86 billion). That is, KN capacity is an unrecognised driver of inflation. A closer scrutiny of Table 2 reveals that ($Y_t > Y_{\text{FS}t}$) for all time periods considered here. Further, the analysis here has been confined to CO_2 pollution abatement. The capacity restriction would have undoubtedly been more stringent had all other sources of KN degradation such as toxic contamination of land and water resource systems and loss of KN endowments because of bush fires and floods were recognised.

3.2. Income and output

It appears that the effects of the GFC were recognised in Australia during Q3-2008 when the observed income paths began their decline. A comparison of incomes (Figure 4 and Table 2b) reveals that the observed income paths for both Y_t and Y_{tS} were in excess of their corresponding expected trajectories until Q4-2008. Subsequent to this period, the observed paths fell below the expected trajectories.

Despite the activation of the stimulus package and the relaxation of monetary policy, from Q3-2008 onwards, the observed paths had not converged with the expected trajectories. However, the decline in Y_t that was prompted by the GFC had not propelled it below Y_{tS} or even the corresponding expected trajectory of Y_{tS}. The rescue measures were put in place well before this could happen. Had policy planning been premised on environmental macroeconomic frameworks, the rescue efforts would have entailed measures pertaining to KN capacity expansion. Besides, rescue measures themselves could have been better articulated towards lifting the paths of Y_{tS} rather than Y_t.

3.3. Employment and wages

Table 3 provides the information on average (quarterly) wages across the eleven quarters considered in terms of both frameworks.

The final two columns portray the per cent reduction in wages that is required for compliance with the outcomes of the environmental macroeconomic framework in terms of prevailing employment (ΔW_{S}) and full employment (ΔW_{SF}). This reduction ranges between 0.44–9 per cent for prevailing employment and 19–25 per cent for the attainment of full employment. Quite clearly the wage reductions required for compliance with both sustainability and full employment are substantial. However, such wage reduction across the board may not be pertinent in the context of some serious distributional issues in Australia raised by Atkinson and Leigh (2007); for example, the

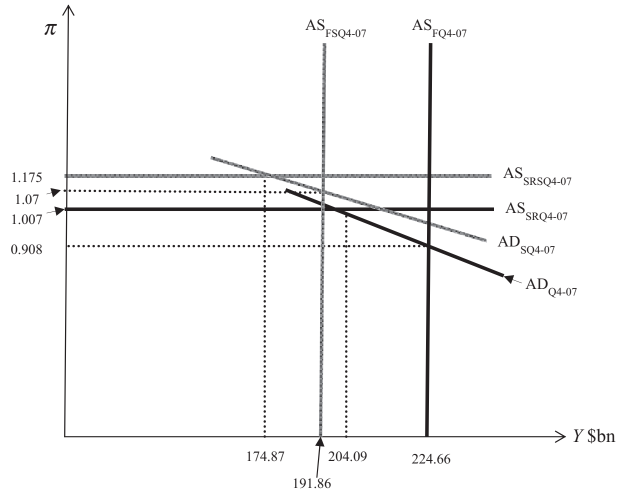

Figure 3 Snapshot of AS-AD framework (Q4-2007).

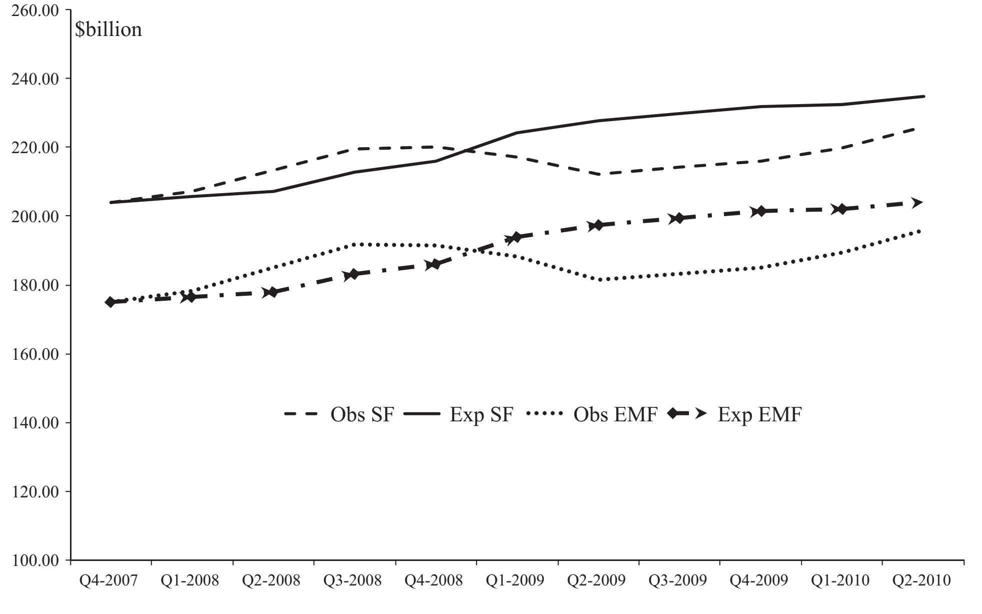

Figure 4 Observed versus expected income levels (Q1-2007 to Q2-2010).

richest 10 per cent held nearly 31 per cent of national income in 2002. The implication of the analysis, here, is the need for exploring the feasibility of a wages policy that combines distributional and sustainability concerns.

4. Conclusion

As illustrated aforementioned, relative to the environmental macroeconomic framework, the application of the standard macroeconomic framework overstates targets and performance. This was illustrated earlier with reference to:

Table 3 Employment and wages

Period	W (\$)	W_S (\$)	W_{SF} (\$)	ΔW_S	ΔW_{SF}
Q4-2007	11772.9273	11361.4438	9521.978824	0.0350	0.1912
Q1-2008	11694.9590	11374.2487	9602.308896	0.0274	0.1789
Q2-2008	11718.4033	11647.1552	9794.653278	0.0061	0.1642
Q3-2008	11938.4172	11885.6062	10008.79045	0.0044	0.1616
Q4-2008	12067.9129	11870.8089	9975.876299	0.0163	0.1734
Q1-2009	12539.7857	11737.9634	9764.203363	0.0639	0.2213
Q2-2009	12679.4267	11419.8108	9478.866235	0.0993	0.2524
Q3-2009	12770.9192	11496.4360	9522.469139	0.0998	0.2544
Q4-2009	12774.9384	11498.1882	9537.93904	0.0999	0.2534
Q1-2010	12636.9522	11553.2272	9647.728997	0.0858	0.2365
Q2-2010	12703.2361	11831.4068	9848.855817	0.0686	0.2247

- The persistence of inflation despite the opposing methods of intervention and the near correspondence between the observed levels of inflation with the levels identified by the environmental macroeconomic framework; and
- The inability of the stimulus to deliver on expected income and employment targets.

The limited effectiveness of the stimulus can be also explained by recourse to the multiplier. For example, the multiplier for consumption expenditure in the context of the standard macroeconomic framework is certainly larger than that of the environmental framework; that is, $\left\{\frac{1}{(1-\beta(1-\tau)}\right\} > \left\{\frac{1}{(1-\beta(1-\tau)(1-\eta)}\right\}$.

Further, the use of the environmental macroeconomic framework would prompt the search for policy initiatives that target the goal of sustainability. Such initiatives would focus on minimising the extent of environmental capital depreciation; and examples of these include the following: the development of renewable and low greenhouse emission technologies instead of further exploration for fossil fuels; and the promotion of innovative closed-loop production systems that re-use wastes and emissions. As indicated, there is also a need to re-visit the subject of wage policy because wage reductions can help attain sustainable income and employment targets. However, such reductions must take cognisance of distributional issues. Finally, environmental macroeconomics may not be as empty as Daly (1991) suggests.

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Appendix

Table A1 (d/d*t*) values for pertinent variables and coefficients. (Based on quarterly data Q1-2001 to Q2-2010)

Variable or coefficient	(d/d*t*)
λ_t	0.998
θ_t	1.002
α_t	1.004
Φ_t	1.0015
β_t	0.996
I_t	1.0114
G_t	1.011
M_t	1.0416
P_t	1.0076
V_t	1.0011
KM_t	1.0125
L_t	1.0063
$L_{\mathrm{F}t}$	1.0054
$P_{\mathrm{KM}t}$	0.992
$r\,(+)$	1.0517
$r\,(-)$	0.922