Carbon Capture and Sequestration: How Much Does this Uncertain Option Affect Near-Term Policy Choices?

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Summary

One of the main issues in the climate policy agenda, the timing of abatement efforts, hinges on the uncertainties of climate change risks and technological evolution. We use a stochastic optimization framework and jointly explore these two features. First, we embed in the model future potential large-scale availability of Carbon Capture and Storage (CCS) technologies. While non-CCS mitigation that reduces fossil energy use is modelled as exerting inertia on the economic system, mainly due to the durability of the capital in energy systems and to technology lock-in and lock-out phenomena, the implementation of CCS technologies is modelled as implying less resilience of the system to changes in policy directions. Second, climate uncertainty is related in the model to the atmospheric temperature response to an increase in GHGs concentration. Performing different simulation experiments, we find that the environmental target, derived from a cost-benefit analysis, should be more ambitious when CCS is included in the picture. Moreover, the possible future availability of CCS is not a reason to significantly reduce near-term optimal abatement efforts. Finally, the availability of better information on the climate cycle is in general more valuable than better information on the CCS technological option.

Keywords: Climate change, Uncertainty, Sequestration, Cost-benefit analysis

JEL Classification: D62, D63, H23, Q29

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1 Introduction

It has become fashionable to assess the potential contribution of Carbon Capture and Sequestration (CCS) technologies to the optimal mitigation of carbon dioxide emissions that is intended to avoid future, dangerous climate change. CCS attracts a lot of attention because it could allow ”to reduce our CO2 emissions to the atmosphere whilst continuing to use fossil fuels” [10]. More precisely, analyses of the optimal timing of CO2 abatement suggest that, after 2050, carbon dioxide emissions could be significantly and increasingly curbed thanks to sequestration [22, 1]. Results in these publications show that, in 2100, sequestration could account for around 40% of the reduction required to stabilize carbon atmospheric concentration to 550 ppmv. In particular, Akimoto et al. [1] present a sensitivity analysis and suggest that this 40% contribution is relatively robust against changes in the CCS costs. In addition, few abatement efforts should be undertaken before 2030 to reach the 550 ppmv stabilization target [22, 1]. This result is confirmed even under an hypothesis of high baseline emissions [1]. Of course, deferring emissions reduction is politically attractive for it avoids requiring explicit efforts from the populations. To policy makers who tend to oppose the notion of early abatement, CCS technologies offer a credible argument for postponing efforts.

However, the opportunity offered by CCS should be envisioned in a perspective broader than that of a cost-efficiency analysis as taken till now. If globally, large scale implementation of carbon sequestration could have a significant impact on our future emissions, should not we take it as a chance to adopt a climate target tighter (and safer) than the doubling of pre-industrial atmospheric carbon dioxide (550ppm)? Previous cost-benefit analyses of CCS in top-down integrated assessment models have focused on forest-based sequestration or on the non-permanency of sequestration [15, 8, 13]. In particular, in Keller et al. [13] the impact on the optimal carbon tax of the availability of CCS technologies is considered and appears to be insignificant before 2100; this also suggests that abatement policies before that date should remain unchanged. However, Keller et al. assume a rather high marginal cost for CCS (100 USD per ton C) which delays the adoption of the option later into the future than more recent contributions suggest [1, 22].

In addition to this, the prevailing scientific uncertainties, in particular about the climate, have implications affecting the optimal strategy for curbing greenhouse gases emissions (see for instance Nordhaus [18, chapter 8], and also [21, 14, 20, 12]) and should be included in the analysis. How largely does CCS future availability impact on the optimal hedging policy?

Finally, CCS singles out from mitigation actions, such as the reduction of energy demand and the switching towards carbon-free energy, that have lasting effects on the future energy input and emission output of the economy (see for instance [5]). CCS implementation does not carry as much transformation of the energy system since it is more like an end-of-pipe activity that can be easily interrupted in the future if global warming concerns fade out. Inertia of energy production and consumption has been pointed to be of concern for defining the hedging policy against the risks of the evolution of the climate [7]. When relying on both CCS and other mitigation options, the optimal hedging policy should therefore account for their dissimilar lasting effects on greenhouse gases emissions.

This article proposes to assess the relevance of the future availability of CCS in the designing of near-term (first decades) abatement policy and in the choice of a climate target. The originality of the approach taken here stands on the fact that the analysis relies on a cost-benefit top-down integrated assessment model, that allows to represent inertia of carbon emission trends and sequential decision in the face of uncertainty and learning about climate risks. This model, named the DISCERNI model[1] is derived from DICE–99 [19].

A number of numerical simulation experiments have been undertaken. In particular, simulation experiments show that two main conclusions can be drawn:

(a) The environmental target that can be derived by applying a Cost-Benefit analysis should be more ambitious (stringent) if CCS is considered as an option that might become available.

(b) The possible future availability of CCS is not a reason to significantly reduce the near-term abatement efforts that would be optimal with no CCS.

We begin with a description of the model in Section 2. Section 3 describes the different scenarios simulated and presents the main results. Section 4 concludes.

2 Model and Simulations Description

The model we used, DISCERNI, is based on the latest version of Nordhaus' DICE [19], and it is an optimal economic growth model of the global economy that includes a climate module linked to carbon emissions deriving from the economic activity. DISCERNI departs from the original DICE in order to account for some key features that are particularly relevant for the purpose for our analysis. In particular, it is structured in order to allow for sequential revision of decisions in the face of uncertainty and learning about climate risks. To this end, it is formulated as a probabilistic optimization problem, which maximizes the expected utility of consumption. After the date of learning, expected utility is conditional on the

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[1] This name is a foreign acronym for 'Double uncertainty on the climate and on the endogenous reduction of carbon itensity'. Only one uncertainty, climate uncertainty, is considered in this article.

knowledge gained. This approach was also used in previous studies as in Nordhaus [18, chapter 8] and in Nordhaus and Popp [20]. The other main change is that the model accounts for technological inertia, a feature that appears to play a significant role in shaping optimal mitigation strategies (see for example Ha-Duong et al. [7]). We represent inertia by making future carbon intensity depending on past abatement efforts whether a constraint on emissions is still active or not, as described in [4] where a calibrated extension of the representation introduced in [9] is proposed.

Finally, and this is the main novelty presented in the paper, as an alternative to traditional abatement effort we allow in the model the possibility of carbon capture and geological sequestration (CCS).

For a formal description of the model the reader is referred to the appendix where model equations are set out. In particular, emissions are modelled as proportional to gross economic output and the carbonization ratio is decreasing over time. However, the central planner can choose the level of emissions through a variable representing the rate of mitigation. This abatement rate is defined in the model as μ; to this is added an alternative decision variable, μ^{CCS}, accounting for the abatement rate due to CCS technologies. CCS is modelled as to produce an impact on the deriving structure of the economy different from that of mitigation. Finally, while the costs of abatement through mitigation remain unchanged compared to the DICE model, CCS marginal costs are different.

The current estimated costs of CCS are rather high. While injection costs are variable and extremely dependent on the reservoir type and on local condition [3], the costs for capture and transport represent the largest part. They are estimated between 35 and 264 USD per ton C for CO2 capture and transport from power plants [22]; for the cement industry, the range is 183–917 USD/tC [10]. Furthermore, costs for capture and transport would decrease through the century, mainly due to learning-by-doing. Besides, the physical potential for storage could be very large: for underground storage[2] alone, global estimates range between 960 and 1,450 GtCO2 (40–390 GtC), while, the capacity of deep saline aquifers is estimated between 6,000 and 10,000 GtCO2 (1,600–2,750 GtC) [Table TS5, IPCC 2005 Technical Report on CCS].

In the model, costs of CCS are assumed to be quadratic in the level of effort with a linear component of 10 USD/tC and marginal costs increasing up to 400 USD, as proposed in [3] by R. Gerlagh and B. van der Zwaan. We take 10 GtC per year as the maximum volume of CCS (corresponding to the marginal cost of 450 USD/tC). Besides, no leakages or auto-consumption of energy are assumed for

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[2] In porous and permeable reservoir stocks, depleted oil and gas fields, and coal beds [10].

[3] R. Gerlagh and B. van der Zwaan, 2004, presentation at the *2nd international workshop on integrated climate models: an interdisciplinary assessment of climate impacts and policies.* 29–20 November 2004, Trieste. 'Instrument choice for a deep cut in carbon dioxide emissions'.

CCS.

Before heading to the results of the simulated policy scenarios, we present in detail the relevant features of the model.

Path-dependency of emissions to past abatement and CCS

In any time period t, the economy tends to emit σ_t units of GHGs per unit of gross output. Emissions to the atmosphere can be reduced either by changes in the production and consumption (for example reducing the input of primary carbon energy) or by capture and sequestration. We denote by μ_t the rate of emission control through economic structural changes and by μ_t^{CCS} the rate of emissions control derived from CCS technologies. As a result, the number of units of GHGs emitted per unit of gross economic output becomes $(1 - \mu_t - \mu_t^{CCS})\sigma_t$ (where $\mu_t + \mu_t^{CCS} \leq 1$).

CCS technologies, on the one hand, and efforts to reduce primary fossil energy consumption, on the other hand, have contrasting impacts on the economy in the long term. Efforts to use less fossil energy imply changes that will last for some time into the future (think for instance to non fossil capacities for electricity production). Therefore, efforts in period t also contribute to the decrease of future trends of uncontrolled GHG emissions[4] per unit of output, $\sigma_{t+1}, \sigma_{t+2}, \ldots$ The advantage of CCS is precisely to avoid such deep and structural changes in the economy that would possibly require costly investments and transformations of consumption habits. CCS efforts at time t do not modify the fossil consumptions but prevent their emissions from spreading and accumulating in the atmosphere. Therefore, in contrast with other mitigation options, investments in CCS technologies at time t have no impact on the future rate of uncontrolled emissions per unit of output.

To portray this in the model, the uncontrolled carbon intensity, σ_t, is defined as a state variable which depends on previous period non-CCS reduction efforts, on previous period uncontrolled intensity and on an exogenous trend. We follow [4] for the description and calibration of the law of motion for σ_t, which is given in the following equation:

$$\sigma_{t+1} = (1 - e)\sigma_{t+1}^0 + e\sigma_t \frac{\sigma_{t+1}^0}{\sigma_t^0}(1 - \zeta\mu_t), \tag{1}$$

where the exogenous trend, σ_t^0, starting at σ_0^0, represent the baseline carbon intensity level, when no control efforts are implemented; μ_t is the decision variable defining the rate of abatement; e and ζ are parameters defined on the interval

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[4] Emissions that are produced at $t + 1$ and in subsequent periods in the case when any policy constraining emissions is removed at $t + 1$.

$[0, 1]$. In particular, e measures the relative importance of the exogenous versus the endogenous part of the process and ζ the share of abatement effort having a long-lasting effect. Conversely, in the DICE model, σ_t is an exogenous parameter fixed to its baseline level, $\sigma_t = \sigma_t^0$; this leads to an overestimation of the optimal emissions, see [4].

The Treatment of Uncertainty

Let us now discuss the issue of uncertainty on the climate. Climate uncertainty is captured by recognizing in the modelling design that today we ignore the true value of the 'climate sensitivity' parameter, i.e. the elevation in temperature for a doubling in GHGs atmospheric concentrations. While yet unknown, the IPCC [11] reports that the value of the climate sensitivity parameter can be included between a range of 1.4 and 4.5 deg C. .

Climate sensitivity is represented by a random variable λ and the model is designed to solve the maximization of the discounted expected utility of consumption (see Appendix B). Once information is obtained, variables in subsequent periods depend on the possible values of the observation.

We approximate uncertainty through a discrete probability implying three states of nature each characterized by a value of the 'climate sensitivity' parameter. The three sample values are chosen in order to offer the best compromise between diversity and 'plausibility' as suggested by Ha-Duong [6]. The samples proposed result in a low ($T_{2x} = 1.4$ deg C), a high ($T_{2x} = 4.0$ deg C) and a central ($T_{2x} = 2.9$ deg C) climate sensitivity. The central value (2.9 deg C) happens to be the parameter value retained in the original DICE 99 model. We have assumed equal probabilities of 33% for these three samples[5]

3 Policy simulations

While our goal is to assess within a cost-benefit model whether the contribution of CCS should be seen as a tool to limit more potential climate damages or as a way to avoid some abatement efforts, it is instructive to start by bringing forward the effect of including CCS into the cost-efficiency version of the model. This version includes the usual exogenous concentration target of 550 ppmv and does not consider climate damages, in order to provide a complete picture of the climate policy cost.

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[5] A uniform probability distribution for these three values of the climate sensitivity belongs to the set of credible probability distributions determined by Ha-Duong [6] using the data on expert's opinion collected by Morgan and Keith [16].

3.1 Cost-efficient policy, the 550 ppmv target

Let us begin by describing the optimal policy that allows to stabilize carbon atmospheric concentration at 550 ppmv. No climate damages enter the objective function and, since the target refers to carbon concentration, uncertainty on the evolution of the temperature does not matter.

When the CCS option is not available, in the DICE model, as well as in the DISCERNI model, the levels of abatement required are quite low. This mainly derives from the fact that baseline emissions grow moderately and reach 15 GtC in 2100, which is a relatively low level when compared with the B2 marker scenario of IPCC SRES [2, 17], where emissions grow over 23 GtC in 2100. Marginal abatement costs are also quite low, and remain under the threshold of 10 USD/tC until 2040 in DICE and until 2070 in DISCERNI. When CCS is available, it enters only after the 10 USD/tC threshold is reached. As a consequence, cumulated sequestration by 2100 is modest (55 GtC in DICE, 7.8 GtC in DISCERNI).

DISCERNI model	2000	2010	2020	2050
Reduction from baseline, except CCS (MtC)				
CCS available from 2030	117	189	288	812
CCS unavailable	133	214	324	894
Δ % CCS vs. no CCS	-12%	-12%	-11%	-9 %
CCS (MtC)	n.a.	n.a.	n.a.	0

DICE model	2000	2010	2020	2050
Reduction from baseline, except CCS (MtC)				
CCS available from 2030	72	130	221	873
CCS unavailable	94	169	287	1,132
Δ % CCS vs. no CCS	-23%	-23%	-23%	-23%
CCS (MtC)	n.a.	n.a.	n.a.	88

Table 1: Effect of CCS availability on cost-efficient abatement. 550 ppm target. DICE and DISCERNI models.

However, CCS availability allows to bypass a significant share of the modest reduction efforts engaged in 2000–2029 (see Table 1 for a summary of the main results). Thanks to future CCS availability, 10 to 20% of those earlier period efforts can be bypassed[6]. Abatement costs decrease even more dramatically (be-

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[6] For a better comparability with the next section, we have also performed this comparison

cause the cost function is a power function): in 2000, abatement costs are reduced by roughly 20% in the DISCERNI model and by 40% in the DICE model.

The 550 ppmv target is central in the debate of mitigation policies. It also turns out to be loosely related to the cost-benefit analysis of the DICE model; in the optimal C-B scenario the model reaches a concentration of 552 ppmv in 2100 but then concentrations grow further during the next century. However, the concern of opposers to a 550 ppmv stabilization target is that it may imply an increase in temperature to undesirable and perhaps dangerous levels. Indeed, if the central value hypothesis for the climate sensitivity parameter turned out to be the more realistic, a 550 ppmv concentration target would imply a temperature rise slightly above 2 degrees Celsius by 2100 that would continue to increase during the next century. Therefore, CCS could be seen as an opportunity to tighten the policy target rather than as an opportunity to postpone efforts to limit concentrations under 550 ppmv. In the next subsection a cost-benefit analysis framework is adopted to explore this question.

3.2 Optimal cost-benefit policy, DISCERNI

The following results (see Table 2) are obtained by applying a cost-benefit analysis using the DISCERNI model with the central value for climate sensitivity (2.9, as in DICE) :

(a) in contrast to cost-efficiency analysis, CCS availability by 2030 brings almost no change to near-term optimal emissions/reductions from baseline, even though the optimal cost-benefit scenario of DISCERNI implies high abatement expenses in the near-term.

(b) After 2030, non-CCS abatement efforts are reduced, but emission reductions deriving from CCS technologies do more than compensate the reduction in standard abatement efforts. Clearly, CCS represents an opportunity to abate larger emission amounts.

(c) Optimal CO2 concentration and temperature levels reached by 2100 and 2200 are reduced when CCS is available. The impact on 2100 levels, however, is modest. (see Table 3).

Since CCS availability as little effect on optimal reductions from the baseline, we can conjecture that this property is still verified when uncertainty on the climate (or on future CCS availability) is accounted for. The next section investigates this point.

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with a concentration target enforced from 2100 and fixed at the optimal level taken from the cost-benefit analysis (see next section) of DISCERNI without CCS available. This time-varying target is more ambitious than the 550 ppmv one and increase the relief offered by CCS availability in DISCERNI: in the near term, 20% of abatement can be bypassed.

DISCERNI model	2000	2010	2020	2050	2100
Reduction from baseline, except CCS (MtC)					
CCS available from 2030	808	1,605	2,440	5,133	9,132
CCS unavailable	815	1,618	2,461	5,170	9,207
∆ % CCS vs. no CCS	-1%	-1%	-1%	-1 %	-1 %
CCS (MtC)	n.a.	n.a.	n.a.	531	1,321

Table 2: Effect of CCS availability on optimal emissions. Cost-benefit analysis, DISCERNI model.

Note that due to the inertia of emissions trends, the reductions from baseline aggregate both currrent reduction efforts and the consequences of past abattement. This second effect dominates when abatement policies have been followed over several decades. For example, in 2050, the current abattement is 2,42 GtC when CCS available, 2,45 when CCS is not available. CCS represents indeed a large part of the currrent effort by 2100 but its impact on abatement is limited.

3.3 Optimal hedging policy, DISCERNI

Uncertainty about climate sensitivity is assumed to be resolved by 2040. After that date, policy decisions depend on the information obtained. Before that date, policy decisions are the same for all states of nature. The results are very close to those of the preceding section; note that total emissions rather than emissions reductions from baseline are now reported (see Table 3 and Figure 1 in appendix A).

In particular, CCS still offers an opportunity to reduce emission more compared to the baseline. This effect is even more pronounced when the information obtained in 2040 reveals that the climate sensitivity parameter takes its ’Central’ or ’High’ value. In particular, in the case where the parameter takes the ’Central’ value and CCS is optimally adopted, the resulting level of emissions is even lower than in the case where no CCS option is available and the climate sensitivity parameter takes the ’High’ value.

An identical comparison exercise has been performed with DICE. In particular, when the climate sensitivity parameter takes the ’Central’ value and no uncertainty is considered, the resulting optimal concentration in 2100 decreases from 552 to 537 ppmv, which corresponds to one decade postponement in the CO2 atmospheric accumulation process.

Finally, the slight difference in near-term policy between scenarios with or without CCS let us conjecture that getting better information on the availability of this option in the future has a small value when compared to that placed on the

	Hedging policy			sensitivity 2.9		
	2000	2010	2020	2050	2100	2200
Emissions (GtC)						
CCS available from 2030	6.565	6.786	6.854	6.038		
CCS unavailable	6.558	6.773	6.835	6.528		
Δ % CCS vs. no CCS	0.11%	0.19%	0.28%	-7.51%		
CCS (volume in GtC)				0.527	1.323	
Other Reductions (volume in GtC)						
CCS available from 2030				1.741	2.427	
CCS unavailable				1.752	2.448	
Δ % CCS vs. no CCS				-0.63%	-0.88%	
Concentration (ppm)						
CCS available from 2030					465	457
CCS unavailable					478	518
Warming (Celsius)						
CCS available from 2030					1.69	2.00
CCS unavailable					1.75	2.31
Cumulated CCS, GtC					61	318

Table 3: Key variables, DISCERNI

possibility of getting earlier and better information on the climate sensitivity to an increase in carbon concentration.

4 Conclusions

As recalled by Holloway [10] the geological storage of CO2 needs to be guaranteed at least ‘until there has been a significant decline in the atmospheric CO2 levels’. Thus the necessary time frame for storage might be in the range of a few hundred years to a few thousand years. In any case, this is ‘greater than the likely lifetime of any corporation’ and raises the issue of liability and of acceptability of this option by the public.

Nevertheless, carbon capture and storage technologies are recognized as a promising and, in many ways, politically attractive way of reducing emissions without dramatically changing the fuel mix or the energy intensity of the economy. The discussion often focuses on the potential cost reduction that could be obtained through learning-by-doing and research and development expenditures and the resulting rates of penetration of such a new technology. In this paper we have taken a slightly different perspective, asking the question of what should the optimal emission strategy be, admitting that the CCS option may become available at reasonable costs in the future.

The first result that can be drawn from the simulation experiments is that the environmental target which can be derived by applying a Cost-Benefit analysis should be more ambitious (stringent) if CCS is considered as a potentially available option. Thus, instead of considering CCS as a future way out of the problem of anthropogenic emissions and their effect on the climate, this technology should be integrated in a broader strategy aiming at modifying the economic structure towards better energy standards and carbon-free fuels. The second main conclusion, strictly connected to the first, is that, the possible future availability of CCS is not a reason to significantly reduce the otherwise optimal abatement efforts to be undertaken in the present and in the near future. The third conclusion concerns the value of getting better information. Previous conclusion let us conjecture that obtaining a better understanding of the climate cycle and of the sensitivity of the climate to changes in atmospheric concentration of CO2 would be more valuable than information concerning the CCS technological option.

These conclusions would be even reinforced, if one considered the issues of auto-consumption of energy and of leakages from the storages.

A Optimal emissions, with an without CCS. Hedging scenario.

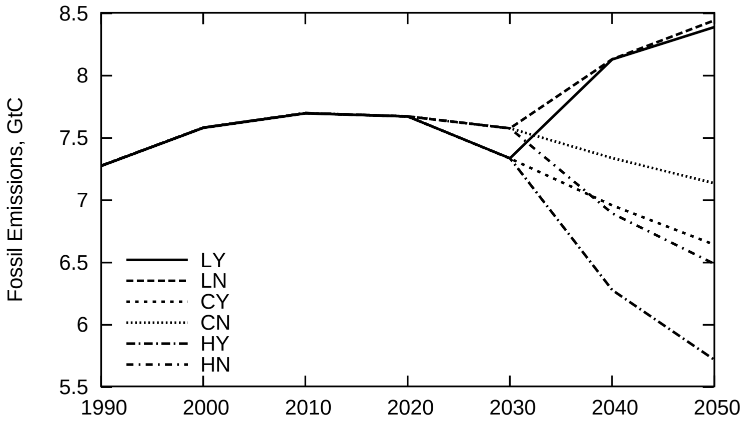

Figure 1: Optimal emissions, with and without CCS

LY : CCS available from 2030, climate sensitivity learned to be L in 2040.

LN : CCS not available, climate sensitivity learned to be L in 2040.

CY : CCS available from 2030, climate sensitivity learned to be C in 2040.

CN : CCS not available, climate sensitivity learned to be C in 2040.

HY : CCS available from 2030, climate sensitivity learned to be H in 2040.

HN : CCS not available, climate sensitivity learned to be H in 2040.

The availability of CCS from 2030 does not significantly modifiy optimal emissions before that date. When climate uncertainty is resolved in 2040, the role of CCS is of greater importance when the climate sensitivity is revealed to be dangerous. Note that in the case with central sensitivity, availability of CCS optimally allows to reduce emissions more than in the case with high sensitivity but no CCS available.

B Summary of the model

The DISCERNI model solves the following problem.

$$\max_{v_0,\dots,v_{d-1}} \mathbb{E}\left\{\sum_{t=0}^{d-1} U_t(c_t) + \mathbb{E}\left[\max_{(v_d(\lambda),\dots,v_T(\lambda))} \sum_{t=d}^{T} U_t(c_t(\lambda) \mid \lambda\right]\right\}$$

Decision: $v_t = (\mu_t, \mu_t^{ccs}, b_t)$ where b_t is the rate of investment

Laws of Motion

Capital Accumulation $K_{t+1} = (1-\delta)K_t + 10 b_t \mathcal{Y}_t(\mu_t, \mu_t^{ccs}, X_t, K_t)$

Endogenous Carbon Intensity $\sigma_{t+1} = (1-e)\sigma_{t+1}^0 + e\sigma_t \frac{\sigma_{t+1}^0}{\sigma_t^0}(1-\zeta\mu_t)$

Atmospheric Concentration $M_{t+1} = \alpha_M M_t + h(X_t) + \beta\mathcal{E}_t(K_t, \sigma_t, \mu_t, \mu_t^{ccs}) + LU_t$

Other Environmental Variables $X_{t+1} = g(X_t, M_t, \lambda)$

Intermediate Variables

Available Output

$$\mathcal{Y}_t(K_t, X_t, \mu_t, \mu_t^{ccs}) = F_t(K_t)(1 - D_t(X_t))(1 - C_t(\mu_t) - C_t^{ccs}(\mu_t^{ccs}))$$

Emissions $\mathcal{E}_t(K_t, \sigma_t, \mu_t, \mu_t^{ccs}) = (1 - \mu_t - \mu_t^{ccs})\sigma_t F(K_t)$

Climate damages for $t < d$ $D_t(X_t) = 0$, for $t \geq d$ $D_t(X_t) = D(X_t)$

Total Consumption $c_t = (1 - b_t)\mathcal{Y}_t(K_t, X_t(\lambda), \mu_t, \mu_t^{ccs})$

The time horizon is $T = 40$. Time step $t = 0$ corresponds to the period 2000–2009. The date of arrival of information, d, to the period 2030–2040.

Initial conditions are K_0, σ_0, M_0, X_0. Cost function C_t is strictly increasing and convex. Utility $U_t = \frac{1}{(1+\delta)^t}\log(\frac{c_t}{POP_t})$. Damage function D is increasing and convex.

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(lxviii) This paper was presented at the ENGIME Workshop on “Governance and Policies in Multicultural Cities”, Rome, June 5-6, 2003

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(lxxiv) This paper was presented at the ENGIME Workshop on “Trust and social capital in multicultural cities” Athens, January 19-20, 2004

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