

UNCERTAINTY AND LEARNING IN SEQUENTIAL DECISION-MAKING:

THE CASE OF CLIMATE POLICY

by

Mort David Webster

B.S.E. Computer Science and Engineering  
University of Pennsylvania, 1988

S.M. Technology and Policy Program  
Massachusetts Institute of Technology, 1996

Submitted to the Engineering Systems Division  
in partial fulfillment of the requirements for the degree of

Doctor of Philosophy

at the

MASSACHUSETTS INSTITUTE OF TECHNOLOGY

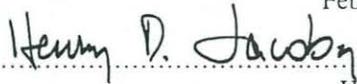
February 2000

© Mort Webster, 2000. All rights reserved.

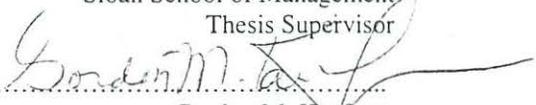
The author hereby grants to MIT permission to reproduce and distribute  
publicly paper and electronic copies of this thesis document in whole or in part,  
and to grant others the right to do so.

Author .....   
Technology, Management, and Policy Program

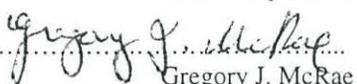
February 29, 2000

Certified by .....   
Henry D. Jacoby

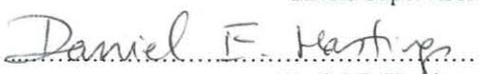
William F. Pounds Professor of Management  
Sloan School of Management  
Thesis Supervisor

Certified by .....   
Gordon M. Kaufman

Professor of Operations Research and Management  
Sloan School of Management  
Thesis Supervisor

Certified by .....   
Gregory J. McRae

Bayer Professor of Chemical Engineering  
Thesis Supervisor

Accepted by .....   
Daniel E. Hastings

Co-director, Technology, Management and Policy Program  
Professor of Engineering Systems & Aeronautics and Astronautics

Accepted by .....  
Richard de Neufville

Professor of Engineering Systems  
Chairman, Committee for Graduate Students

UNCERTAINTY AND LEARNING IN SEQUENTIAL DECISION-MAKING:  
THE CASE OF CLIMATE POLICY

by

Mort David Webster

Submitted to the Engineering Systems Division  
in partial fulfillment of the requirements  
for the degree of Doctor of Philosophy  
at the Massachusetts Institute Of Technology

February 29, 2000

**Abstract**

The debate over a policy response to global climate change has been and continues to be deadlocked between 1) the view that the impacts of climate change are too uncertain and so any policy response should be delayed until we learn more, and 2) the view that we cannot wait to resolve the uncertainty because climate change is irreversible so we must take precautionary measures now. The objective of this dissertation is to sort out the role of waiting for better information in choosing an appropriate level of emissions abatement activities today under uncertainty.

In this dissertation, we construct two-period sequential decision models to represent the choice of a level of emissions abatement over the next decade and another choice for the remainder of this century, both empirical models based on a climate model of intermediate complexity, and analytical dynamic programming models. Using the analytical models, we will show that for learning to have an influence on the decision before the learning occurs, an interaction must be present between strategies in the two decision periods. We define an "interaction" as the dependence of the *marginal* cost or *marginal* damage of the future decision on today's decision. When an interaction is present and is uncertain, the ability to learn will introduce a bias in the optimal first period strategy, relative to the optimal strategy if the uncertainty would never be reduced. In general, the bias from learning can be either in the direction of higher or lower emissions, depending on the sign of the interaction and the probability distribution over damage losses relative to abatement costs.

We demonstrate using the empirical climate decision models that the difference between optimal emissions abatement today with and without learning is insignificant. The reason is that the IGSM, like most other climate assessment models, omit many of the most important interactions between emissions today and marginal costs or damages in the future. We show that by representing possible interactions, such as induced innovation from policy constraint or the effect of emissions growth on ocean circulation, that learning will have an influence on today's decision, often in the direction of *lower* emissions if we expect to learn. In general, the "wait-to-learn" is not necessarily a valid argument for delaying a climate policy that constrains emissions.

Thesis Supervisor

Henry D. Jacoby  
William F. Pounds Professor of Management  
Sloan School of Management

Thesis Supervisor

Gordon M. Kaufman  
Professor of Operations Research and Management  
Sloan School of Management