1. INTRODUCTION

1.1 BACKGROUND

The impacts on the natural environment have increased in spatial scale and duration in the last few decades. Up to the middle of the twentieth century, environmental problems were mostly limited to local or regional impacts (the first phase of environmental problems). During the 1960s the second phase, an increasing output of synthetic chemicals into natural processes, became the main focus of concern as evident in Carson's work *Silent Spring* (1962). The concern for the environment entered the discourse of economic theory and policy making, but has been treated as externalities to a socio-economic system that could be treated at economically reasonable costs and politically realistic time and space scales. According to Clark and Holling (1984:477), the third phase is evident now: *a period of chronic, global, and extremely complex syndromes that threaten to constrain and even reverse progress in human development.* This emerging third phase is evident in studies such as *Limits to Growth* by Meadows *et al.* in 1972 and the Bruntland Report in 1987 (WCED 1987), and has entered the international sphere of policy making through the United Nations Conference on Environment and Development in Rio de Janeiro in 1992. Examples of such global environmental problems are ozone depletion, loss of global biodiversity, desertification and the problem referred to in this study: global climate change. The latter is addressed on a global level through the Kyoto Protocol which was drawn up in 1997 and is still open for ratification. On 7 September 2000 only 29 countries, all developing countries, have ratified the Protocol, while 84 governments have signed it (UNFCCC 2000).

Global climate change is an example of a complex and dynamic environmental problem. It is complex in the sense of the large amount of interrelationships and dynamic in its temporal and changing character. The scientific theory is that global climate change is caused by an increasing concentration of greenhouse gases (GHGs) in the atmosphere. The main greenhouse gases (GHGs) are carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), chlorofluorocarbons (CFCs) and ozone (O_3). Scientists have long suspected that changing the composition of the atmosphere would alter the earth's climate (Arrhenius 1896; Tyndall 1863). Nowadays, this **enhanced greenhouse effect** is one of the best known global environmental issues. According to the Intergovernmental Panel on Climate Change (IPCC), temperatures are expected to rise between 0.8 °C and 3.5 °C in the 21st century (Houghton *et al.* 1996). Although the magnitude of global warming is disputed it appears that there is some consensus that the extremes (longer and more intensive droughts and more catastrophic floods) are worsening. The IPCC identified five key areas of vulnerability to climate change: terrestrial and aquatic ecosystems, hydrology and water resources, food and fibre, human infrastructure and human health (Houghton *et al.* 1996). However, the exact nature of the global climate change problem is very difficult to comprehend. The

uncertainty and complexity in the debate on global climate change have been emphasised in several publications (Bruce *et al.* 1996; Munasinghe *et al.* 1995). For instance, the impacts are occurring over very long time frames. Climate processes are also characterised by poorly understood feedback processes associated with clouds, oceans, sea ice and vegetation. The damages caused by GHGs occur as a result of the total atmospheric concentration at any particular time, which is a function of the cumulative level of emissions. The GHGs differ in their atmospheric lifetimes, thus complicating the calculation of the physical impact of an increase of GHGs on atmospheric concentration. The chain of events leading to global climate change is also non-linear in character making it almost impossible to characterise expected changes in probability distributions (Munasinghe *et al.* 1995:37).

Global climate change is also an example of an environmental problem that is influenced by economic activities and has an impact on economic activities. This makes it an economic problem and one that can possibly be addressed through economic policy making. A recent report of the Intergovernmental Panel on Climate Change (IPCC) states that the balance of information suggests that **human activities** have a discernable impact on the earth's climate (Houghton *et al.* 1996)[1]. The emissions of greenhouse gases are directly linked to various **economic activities** such as energy generation, transport, industrial activities such as cement manufacture, the burning of biomass, and land-use changes such as agriculture. CO_2 is the major contributor to global warming, with most of the CO_2 emission coming from the combustion of fossil fuels such as coal, gas and petroleum.

Global climate change cannot be separated from economic activities that are entrenched in most of the world's economies. Since global climate change is intertwined with the basic features of economics and development, or sustainable development, it cannot be analysed in isolation (Duchin 1996; Howarth & Norgaard 1992:473). Pearce (1998:3) terms this **practical environmentalism** – the possibility of saving the world's environments can only done by modifying and reforming the way the world economy and national economies are managed. The aim is to get significant improvements in the natural environment through real world policies. Policy making towards global climate change should therefore include the economic realities of the different regions and countries.

South Africa is not excluded from the problem of global climate change. There are three prominent reasons for this. First, South Africa relies heavily on the combustion of fossil fuels, especially coal, for energy generation (Rowlands 1996:23), and is listed as the fifteenth highest emitter of CO_2 in the world. South Africa's emission of 8.5 tonnes of CO_2 per capita is on par with that of the European Union and far above the world average of 3.97 tonnes of CO2 per capita (UNEP 2000). Second, the vulnerability to global climate change is regionally diverse with developing countries, and especially African countries, expected to be most significantly impacted. Southern Africa is particularly vulnerable due to its aridness

[1] See Goudie (1990:262-303) for a discussion on the main mechanisms of human influence on the climate system.

(Rowlands 1996:23). Third, South Africa has signed the Kyoto Protocol and is thereby drawn into international negotiations on climate change policy.

The economic approach to environmental policy was initially set in the literature on pollution control following Pigou's suggestion of a tax to internalise external effects of economic activity (see Freeman 1998). Economists saw the problem of pollution as one where economic agents impose external costs on society. The obvious solution was to place an appropriate price (Pigouvian tax) on polluting activities in order to internalise the social costs (Baumol & Oates 1988:1). In later years the focus has become broader through a refinement of price-based approaches and also the acceptance of quantity-based approaches such as marketable permits (Baumol & Oates 1988). The economic literature on environmental policy making was increasingly drawn in the direction of demonstrating relative costs and benefits of alternative economic approaches to environmental problems, and finding the optimal mix between available instruments against different sets of criteria.

It seems that the debate on a conceptual economic approach for environmental policy on complex and dynamic environmental problems, such as global climate change, has reached a stalemate. The policy advice to complex environmental problems such as global climate change is often based on different, often opposing theoretical paradigms or schools of thought. Based on **pre-analytical** normative criteria such as efficiency, sustainability or survival, economists offer policy advice that only re-emphasise their initial, often implicit, normative assumptions. When the norm of economic efficiency is used, the costs and benefits of global climate change need to be expressed to inform an optimal policy approach. However, the complexity of the issue complicates monetary estimations of the damages of GHG emissions. The best that can be done is to estimate the order of magnitude of the impact of climate change (Tol 1996)[2]. According to Fankhauser (1996), a doubling of CO_2 levels would lead to damages accounting for roughly 1 – 2.5 per cent of GNP per year, but increasing to a range of 2 – 9 per cent of national GNP in developing countries[3]. However, given the uncertainty and complexity of the climate change issue, the models underlying these estimates have to rely on subjective judgements that are not amenable to empirical testing. For example, Howarth & Monahan (1996:187) argue that an operationalisation of economic efficiency through cost-benefit analysis is ill-equipped to cope with pervasive uncertainties and temporal aspects such as intergenerational fairness. The debates on appropriate policy responses would involve *fundamental disputes concerning social values and the role of science in policy analysis* (Howarth & Monahan 1996:187). Another example is that the World Resources Institute

[2] See Tol (1995), Cline (1992), Fankhauser (1995, 1996), Nordhaus (1994) and Titus (1992) for monetary climate change damage estimates to the United States, and Fankhauser (1996, 1995) and Tol (1995) for an estimation of climate change damages across different world regions.

[3] These calculations are disputed for not giving information on the marginal damage costs of GHGs (Fankhauser 1996) and the dynamic shape of the damage function (Tol 1996), and therefore should only be interpreted as very rough orders of magnitude.

(WRI) concluded that the costs of greenhouse gas emissions depend almost entirely on the assumptions used in economic models. The key assumptions in these models account for more than 80 per cent of the differences in economic predictions (WRI 1997). Azar (1996) also points out that most models of the long-run cost of reducing CO_2 assume the costs and performance of energy supply technologies to be exogenously specified. If the recent developments in the area of new growth theories contain any grain of reality, these models are exogenising one of the fundamental forces behind economic growth (Sengupta 1998). Others have pointed out that these models are much too simple to use empirically (Barker 1996; Hennicke 1997). Hennicke (1997) demonstrated that the results from the dynamic integrated climate-economy (DICE) model (see Nordhaus 1994) are very sensitive to variations in the discount rate, the utility function, the rate of energy efficiency, CO_2 intensity and assumptions on economic growth. Nordhaus (1994:97) himself points out that there are many possible extensions of the DICE model, for instance, a better representation of the damage function, an inclusion of other potential market failures such as ozone depletion, air pollution and research and development, and an inclusion of issues of uncertainty in the model.

In summary, it seems that economic approaches to complex and dynamic environmental problems have fundamental problems that could prevent optimal approaches to complex and dynamic environmental problems such as global climate change. This **pre-analytical blindness**, so to speak, could have disastrous effects as illustrated by Maslow (1966) (quoted by Janssen 1998:3-4): *If the only tool you have is a hammer, you tend to treat everything as if it were a nail.*

1.2 RATIONALE

The rationale for developing a conceptual framework for economic policy-making approaches to complex and dynamic environmental problems stems from three perspectives:

- the current standing of positive political economy
- recent developments in the physical sciences
- the role of different types of knowledge in problem solving

First, the current standing of positive political economy. The flourishing economic-philosophical argument is that economics is a well-defined science underpinned by realistic assumptions. This positive approach to economic problems is definitive and realism cannot be an independent criterion (see Hahn & Hollis 1979:2). The application of the positive economic approach to policy making was outlined by Keynes (1917) in his book *The scope and method of political economy*. He urged the importance of *recognising a distinct positive science of political economy* (Friedman 1953:3). The stage was set for the further development of economic political theory and, therefore, subsequently economic policy-making approaches to issues pertaining to the natural environment. To paraphrase Friedman (1953:4): *Positive economics is in principle*

independent of any particular ethical position or normative judgements. As Keynes says, it deals with "what is", not with "what ought to be". Its task is to provide a system of generalisations that can be used to make correct predictions about the consequences of any change in circumstances. Its performance is to be judged by the precision, scope, and conformity with experience of the predictions it yields. In short, positive economics is, or can be, an "objective" science, in precisely the same sense as any of the physical sciences. The link between economics and scientific objectivity has been made and translated into the realm of economic approaches to policy through specific welfaristic decision rules such as Pareto optimality. Such approaches have been standard in approaching economic policy issues ever since.

However, the methodology of positive economics has not remained unchallenged in economic thinking. Several scholars have asked questions on the nature of and the assumptions underlying positive economics (Hahn & Hollis 1979; Blaug 1992, 1980; Boland 1982; Caldwell 1982; Eichner 1983; Bromley 1991, 2000). However, their common critique that economics cannot make a claim to scientific objectiveness and ethical neutrality has not been taken seriously in economic approaches to environmental policy. The question still remains: what would an economic policy-making approach to complex and dynamic (environmental) problems look like, without falling into the trap of *adorning itself with the fig leaf of hard-headed positivism* (Ward 1972 as quoted in Blaug 1992:238). The distinction between *what is* and *what ought to be* cannot be separated easily in such problems. Approaching economic policy to complex and dynamic problems would involve a rethink on Keynes' **positive science of political economy**.

This study is done in acknowledgement of the need for abstraction in approaching complex and dynamic environmental problems. Nevertheless, this quest for scientific abstraction needs to internalise the ability of such approaches to explain reality. Both the complexity of environmental problems such as global climate change and the potentially far-reaching impacts of economic policies on environmental problems necessitate a cautious economic approach to environmental policy making. As mentioned in the previous section, current economic policy advice is based on the normative criteria that underlie different theoretical approaches to economic and environmental reality. The pre-analytical framework needs to be exposed and internalised in a policy-making approach to complex and dynamic environmental problems. Based on recent scientific information, it is also accepted that complex and dynamic environmental problems, especially climate change, are caused by economic activities and could therefore be addressed through economic approaches to environmental policy design.

When acknowledging the complexity and dynamics of environmental problems such as global climate change, the approach towards such problems would change. In such cases the theories that inform policy making are critically examined for their appropriacy to deal with the problem. A theory is just a theory – nothing more and nothing less; theories come and theories go. Frazer (1854-1941), a British anthropologist, once said (as quoted in Jones (1994:90): *It is the fate of theories to be washed away….I hold them all very lightly, and have used them chiefly as convenient pegs on which to hang my collection of facts.* If any particular

theory proves less useful in dealing with complex environmental problems, the next question is whether the right questions are being asked in the first place. The question Dopfer (1976) asked remains relevant: Is the current paradigm a basis which calls for the right kind of questions, allows for the formulation of relevant theories, suggests an appropriate degree of empirical testing, and, ultimately, proposes meaningful solutions to the most pressing problems of the future? Myrdal (1977) echoed this sentiment: It is better to have imprecise or approximate answers to the right questions than have precise answers to the wrong questions. A critical examination of the assumptions and limitations of the various theories underlying policy-making approaches becomes a necessity in the case of complex and dynamic environmental problems.

On an anecdotal note: at the heart of an explanation why theories need to be critically examined is one of Alice's discoveries in Wonderland. She held her hand on the top of her head to feel which way she was growing, and was quite surprised to find that she remained the same size[4]. To measure a change one needs a measuring tool external to the system that is being measured. One could theorise on the efficiency of Alice's growth or whether she will survive the growth process altogether, but these theories are bound by the internally pre-defined criteria of measuring Alice's change. One can judge on better theories, but only by comparing those that are competing within the same predefined measuring rod. There is no **a priori** reason to believe that one of these pre-analytical theoretical criteria holds any truth-values.

Secondly, the rationale for this study stretches wider than questioning economic approaches to environmental policy within economic science alone, and includes contributions in the physical sciences on the complex and dynamic character of reality, as well as ways to respond to these new insights. The question on the unification of different, often opposing theories, has been prominent for decades in the physical sciences. For instance, in the physics of the 1920s, Heisenberg unified Schrödinger's theory of waves with the then current paradigm of a theory of quanta to lay the basis for quantum mechanics, but pointed out that a study of this unified theory is hampered by the **uncertainty-principle**. This means that a study of the **fixed** nature of quanta can only happen at the expense of information on direction and speed of these quanta and a study of the **change** in quanta can only be at the expense of information on the nature of these quanta. A recent book *The end of physics. The myth of a unified theory* by Lindley (1993) questions the physicist's notion of a theory of everything (TOE). He concluded that Einstein's dream (see Barker 1986), a theory that would unify the universe, is practically unattainable. Lindley (1993:20) further warns against the dangers of an attempt where mathematical elegance is running away from pragmatic verification: *What is the use of a theory that looks attractive but contains no additional power of prediction and makes no statements that can be tested? Does physics then become a branch of aesthetics?*

[4] For *Alice in Wonderland* with philosophical footnotes, see Heath (1974).

This search is nothing more than a faith in the unlimited rationality of the human mind. Planck (1981) described this scientific faith in the rationality of nature: *...over the entrance to the gates of the temple of science are written the words: Ye must have faith.* This faith in rationality, when applied to the TOE cannot be tested empirically. The human mind alone cannot truly grasp the full complexities of such an undertaking: *As philosophers have frequently found, the real world seems too messy, too stubbornly arbitrary, to be found out by the power of thought alone, no matter how fine the guiding sense of aesthetics* (Lindley 1993:231). Complete unification in physical sciences is hampered both by practical and cognitive aspects.

Does this critique on unification between theories in the physical sciences also apply to the economic sciences? This question is very relevant because if a unified economic approach to complex and dynamic environmental problems could be derived, it could serve as the basis for an integrated approach to policy making. The answer to this question would determine the methodology used to approach policy making for complex and dynamic environmental problems. One could argue that the economic theories are not based on rational thought alone, as the results of empirical verification and falsification are just as important. Nevertheless, the realisation that the world is a system, containing interlinking and overlapping systems such as ecosystems, economic systems and political systems makes one cautious to have absolute faith in any one particular theory. Different competing theories may be verified or falsified, depending on the criteria for measurement and the part of the systems under study. While physicists are criticised for their faith in the power of thought alone, economists cannot escape the verdict by resorting to both rational thought and empirical verification. Kapp (1961:49) has warned against the dangers of unverifiability in the unification of inquiries and various spheres of knowledge. The systems under observation may be too complex and too dynamic to optimise **ex ante** in a set of defined criteria. It has been argued that an approach to economic concepts such as sustainable development, that accepts the diversity of theories, might have a better chance in providing quality information to the policy-making process (see Norgaard 1985). Nevertheless, without making an **a priori** judgement at this stage, different theories on economy-environment interactions will have to be evaluated for their contribution to an integrated approach to policy making.

Thirdly, apart from the interrelationship between economic systems and environmental problems such as global climate change, and the contributions of the physical sciences to the unification debate, another rationale exists for this study. This rationale relates to perceptions on the place of different kinds of knowledge for policy-making purposes. Feyerabend's critique on the absolute use of one kind of knowledge, most notably science, provides another rationale to approach policy-making issues without a predefined theoretical framework (see Preston 1999). He argues that scientific rationality is being judged, rather than being used as a basis for judging everything else (Preston 1999:10). For example, judging whether economic approaches to complex and dynamic environmental problems are appropriate is, in fact, an appeal to a set of values external to the economic or environmental systems themselves. To think that such values could be drawn from economic approaches to policy making themselves, or that

economists or sociologists or ecologists are the only people who are competent to assess science, is to lapse into what Feyerabend calls **elitism** (see Preston 1999:14). Where to seek the ultimate values to judge the righteousness of science, economics, management or politics is ultimately an article of one's deepest values or belief sets. For example, Popper sought these values in logic, Feyerabend in the ethics of democratic relativism and Dooyeweerd in Biblical norms and values.

1.3 PROBLEM STATEMENT AND OBJECTIVE

Economic approaches to environmental problems appear to be ill-equipped to address complex and dynamic environmental problems. Various limitations of economic approaches to global climate change have been pointed out in section 1.1. Due to the interrelated nature of economic and complex, dynamic environmental systems, the wrong policy advice could have high opportunity costs to the economy, the environment or even both. Governments need the best economic policy advice on complex and dynamic environmental problems, advice that is sensitive, at least, to the pre-analytical criteria of different economic theories on the environment, the developments in the physical sciences on approaching complex and dynamic problems, and the relative truth-value of different knowledge categories. This brings us to the objective of this thesis: The objective of this thesis is to develop a conceptual framework for economic policy making on complex and dynamic environmental problems.

The aspects of such a conceptual framework would include aspects not entrenched in current economic approaches to environmental policy making: an evaluation of the pre-analytical normative criteria of economic theories, principles for approaching complex and dynamic problems, and ways to deal with various types of uncertainty.

The key question for this research is: **How can economic policy making in the case of complex and dynamic environmental problems such as global climate change best be approached?**

The research question is divided into the following hypotheses:

- Economic theories on the environment are sufficient to inform economic policy on complex and dynamic economy-environment interactions.
- An application of economic theory to the concept of sustainable development provides an adequate integrative framework to inform economic policy on complex and dynamic economy-environment interactions.
- Public policy approaches for environmental problems are sufficient to internalise complex and dynamic economy-environment interactions.

1.4 METHODOLOGY AND STRUCTURE

The study is primarily a literature study drawing on various disciplines, most notably economics, public choice, policy science, complexity theory and systems theory. Following Phillips and Pugh's (1994:50) categorisation of types of research, this thesis can be categorised as **problem-solving research**, as opposed to **explanatory research** or **testing-out research**. This means that many different intellectual resources are brought to bear on a solution, acknowledging a real world that is changing all the time[5]. Furthermore, the research methodology is, as a consequence, inductively orientated. An approach for economic policy making in case of complex and dynamic environmental problems is drawn from a set of various theories on economics, environment and policy and not deduced from predetermined premises.

The thesis comprises eight chapters. In Chapter 2 the focus is on the circumstances under which economic thought on the natural environment has developed. In this chapter the character of reality, as perceived in Western philosophy, religion and science and the implications for economic thought on the natural environment are examined. It is suggested that a unified approach to economic policy making for the natural environment would encounter many difficulties as revealed by underlying tensions between different philosophies, notably the biased focus on either substantivist or processional aspects of reality.

Based on the conclusions of Chapter 2, Chapter 3 takes a pluralistic point of departure on the contributions of various theories on economy-environment interactions. The key elements of these different theories to policy making for complex and dynamic environmental problems are discussed and the **status quo** in climate change policy making is highlighted. The various aspects of complexity and dynamics in economy-environment interactions are further worked out in addition to specific theories on these interactions. It is concluded that not one theory on economy-environment interactions is likely to include the complexities of economy–environment interactions and this would hold even more true for large scale, **global** environmental problems such as climate change.

The next question, whether the concept of sustainable development would provide an adequate framework for economic policy making, therefore including both aspects of substance and process, is addressed in Chapter 4. It is highlighted that the concept of sustainable development is not a unifying concept that could serve as basis for economic policy making on complex and dynamic environmental problems, but is just as fragmented as the particular theoretical framework in which the analysis is carried out. The need therefore still exists for an organisational framework for approaching economic policy making for complex and dynamic environmental problems.

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[5] Explanatory research is involved in the tackling of new problems/issues/topics about which little is known, while testing-out research focuses on finding the limits of previously proposed generalisations.

In Chapter 5 the systems approach is discussed as a potential organisational framework for complex and dynamic problems. Drawing on the literature of systems theory and ecological systems, it is concluded that the concept of sustainable development can be organised according to systems theory principles. Economic, socio-cultural and ecological aspects of complex and dynamic environmental problems should therefore be approached on a case-by-case basis. These aspects could be organised as nested subsystems, equal trade-offs, or co-evolutionary interdependence, depending on the type of complexity evident in the problem.

Based on the conceptual theoretical framework developed in Chapters 2-5, in Chapter 6 the added complexity of economic policy making is included in addressing complex and dynamic environmental problems. The question is asked whether any economic policy or public policy framework provides an integrated framework for approaching complex and dynamic environmental problems. The key elements for the design of policy in such cases are identified. It is argued that most policy frameworks are static *or* dynamic in character, with a narrow emphasis on one aspect of complex and dynamic problems.

In Chapter 7 a meta-level policy learning framework is suggested to internalise both aspects of complexity and changing realities of environmental problems. Such a learning framework for economic policy is critically evaluated in the context of complex and dynamic environmental problems such as global climate change. Furthermore, the current economic approaches to global climate change policy are compared to the key features of such a learning framework.

Chapter 8 concludes the study by highlighting the key learning points, evaluating the limitations of such a policy learning framework and making recommendations for further research.