# Industrial Innovation *and* Environmental Regulation

## DEVELOPING WORKABLE SOLUTIONS

*Edited by Saeed Parto and Brent Herbert-Copley*

# Industrial innovation and environmental regulation: Developing workable solutions

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# Introduction

*Saeed Parto*

Since the industrial revolution and until around the mid 1960s, the environment and environmental issues were viewed as secondary to economic development and technological progress. A polluted river or lake or ravaged countryside was a sign of progress and prosperity. The full extent of the negative impacts of industrial activity was unknown and therefore not a policy concern at any level. The environmental awareness that began in the 1960s culminated in a series of national and international forums on the links between economic development and the environment and the importance of environmental protection at a global scale. There was increasing recognition that the unprecedented environmental problems of the time had been caused by accumulated pollution from intensive industrial activity over many decades; pollution that contaminated food, fodder and water resources and endangered humans and other species.

The current focus on the environment and environmental protection has its roots in the period between 1965 and 1970. A series of highly publicized environmental accidents and persistent problems such as acid rain and surface- and groundwater contamination in numerous countries in the industrialized North led to a proliferation of environmental groups, followed by a series of legislative measures aimed at curbing pollution at the business enterprise and public utility levels. The period of politicization that ensued saw environmental non-governmental organizations (ENGOs) and business corporations pitted against each other as the main protagonists, with governments often acting in a catch-up mode initially

and later as the arbitrator of the conflicts. By the late 1990s these roles had evolved in many industrialized and industrializing countries. Many governments had begun a move away from introducing reactive and output-oriented regulations to deal with acute environmental problems and toward interactive regulatory regimes and process-oriented regulations. Many business enterprises employed highly sophisticated techniques to manage their environmental impacts and undertook lobbying to ensure that environmental regulations caused minimal interruption to normal business activity. In the meantime, NGOs in some industrialized countries made themselves available to work with willing government and private-sector actors toward meeting shared environmental objectives.

Although the history of environmental regulations goes back a few centuries, the modern era of environmental regulation began in the early 1970s. Since then environmental regulation (or the threats thereof) has been used with increasing intensity and sophistication as a main instrument of steering the behaviour of economic agents in industrial production. The purpose of environmental regulation has been to coerce producers of goods and services into internalizing environmental costs of production. These attempts have not gone without facing opposition on practical and ideological grounds. For example, a report by the United States' Joint Economic Committee (JEC) in 1996 argued that as far as firms were concerned, environmental regulations were no different from taxes as they were both costs to be incurred over and above the ''normal'' production costs. Furthermore the report argued that environmental regulations were not conducive to innovation because ''the very nature of innovation is its unpredictability [and] future innovations cannot be directed by bureaucrats'' (JEC, 1996: 2).

The arguments for environmental regulation are usually based on what has come to be known as the ''Porter hypothesis''. In addition to recognizing the need for environmental regulation to address acute and chronic environmental problems, Porter (1991, 1996) and Porter and van der Linde (1995) push the envelope further by suggesting that at least in some sectors carefully designed environmental regulation as a key feature of industrial policy can increase firm competitiveness by encouraging innovation in environmental technologies. This could be particularly the case if environmental regulations are products of interactive and systems-based policy thinking and policymaking. Whether environmental regulation leads to more or less innovative activity remains a contested issue among commentators from government, industry and academia, however.[1] There are numerous case studies in support and rejection of the Porter hypothesis.[2] Interestingly, in some cases the hypothesis is used to argue for (unregulated) environmental management through voluntary

initiatives by firms since the potential economic advantages of cleaner production are viewed as providing sufficient motivation for firms to clean up and potentially innovate to protect the environment.[3] Regardless of orientation, all the arguments and counter arguments are premised on the recognition that environmental regulations represent a significant factor in shaping the environmental behaviour and economic performance of industrial firms and in setting the parameters that determine the environmental sustainability of the economic system.

As far as the interplay between environmental regulation and innovation is concerned, three overlapping features of the Porter hypothesis are worth highlighting.[4] First, the hypothesis emphasizes outcomes and not processes and thus excludes process innovation. Second, regulations may constrain ''normal'' profit-making activity and force firms to explore uncharted profit-making territories and to become innovative in taking advantage of new opportunities. Finally, environmental regulations could act as shocks to the normal operations of the firm, inducing it to innovate for compliance and profit maximization. The economic costs and regulatory ramifications of these outcomes have important implications for innovation policy. However, these features of the hypothesis are difficult to investigate systematically (Jaffe and Palmer 1996) due to the inadequacies of the available data and are perhaps best tested in context-specific case studies. In addition, the Porter hypothesis rather neglects the institutional context of environmental innovation since Porter, like most of his critics, views the regulations-innovation nexus in a linear fashion and as something that is singularly ''good'' or ''bad'' for innovation, competition and sustained economic growth.

A broader view of environmental regulations characterizes them as one element in a plethora of ''institutions'' that collectively structure social interactions and economic transactions through redefining (or steering) firm behaviour and economic activity as a whole. Some have argued that the new environmental awareness among economic actors, the proliferation of new or adapted technologies to address environmental problems, and reduced materials use combined with evolving environmental regulations constitute ''ecological modernization'' of industrial activity (see Mol and Sonnenfeld 2000; Murphy 2000)[5] while others have used the term ''transition'' (see Kemp, this volume) to conceptualize this transformation. A key point of departure for the proponents of ecological modernization theory and transitions is that improvements in environmental well-being can be achieved through technological advances and other forms of innovation leading to increased efficiency in systems of production and consumption.

The (largely) retrospective perspectives of ecological modernization and transitions are based on the transformation process to which the en-

vironmentalism of the 1970s has been subjected. The loosely organized and NGO-based environmental movement of the 1970s had become, by the late 1980s, a largely institutionalized source of information dissemination on significant environmental issues for a host of actors, including regulatory agencies. By the early 1990s it had become apparent that many of the environmental problems targeted by policymakers required more than end-of-pipe solutions and incremental innovation. Increasingly, environmental scholars and policymakers were using such terms as paradigm shift, regulatory reform, regulatory regime change, structural transformation and ecological modernization.

For the most part the new vocabulary was more reflective of the political implications of environmental protection and environmental policymaking. The move toward liberalization coupled with the continued failure of the market to protect the environment as a public good resulted in a dialogue involving the private and public interests on the role of governments in environmental protection and improvement. ''Transition management'', adopted as a policy style by the Dutch government, and ecological modernization, adopted by the red-green German government since 1998, are products of this dialogue in the European context. Elsewhere, numerous countries in the north and south have adopted environmental policies and issued comprehensive formal statements on their commitment to environmental protection and sustainable development.

The complexities of the environment-economy relationships disallow ''one-size-fits-all'' solutions to similar environmental challenges in different contexts. It would be naïve to expect that the Dutch or the German deliberative policy styles could be readily adopted by other countries since there are fundamental differences among the modes of governance and stages of economic development that characterize the different nation states. To be successful, an environmental policy has to resonate with the formal and informal institutions through which governance is exercized. The long tradition of democratic and participatory modes of governance in Nordic and western European countries is not present in many countries experiencing similar environmental challenges. For example, in Taiwan (see Yap et al., this volume) environmental policy, much like other policies, is implemented in a top-down fashion by a rather paternal state apparatus that systematically induces firms to invest in process and product innovation including environmental technologies. Historically, inducement in the case of Taiwan has employed both regulatory and non-regulatory incentives.

Regardless of how regulatory and other changes have come about in each of the cases in this volume, it is clear that in every case a transition or a significant degree of ecological modernization has taken place. The transformation in each case has been problem-driven and, in some

cases, achieved through deliberate planning. For example, as Chudnovsky and Lopez illustrate in chapter 3 the structural transformation of the Argentinean industry took place in response to exogenous economic factors but yielded direct environmental benefits as various sectors needed to modernize in order to remain competitive. The need for modernization led many firms to adopt technologies with superior environmental performance. A similar point is made by Herbert-Copley (this volume) in the case of Canada's pulp and paper industry. The case studies in this volume illustrate the need to adopt a non-linear perspective on the evolution of environmental regulatory change and environmental innovation. To attend to this need we utilize the notion of transitions and draw on the institutionalist literature to provide a more encompassing view of the environment-regulation nexus.

The remainder of this introductory chapter is organized as follows. We reconceptualize the notion of transitions from systems and institutional perspectives and then proceed to provide a summary of the case studies to underline the extent to which the notions of transitions and institutional change can assist us to understand environmental regulatory change and its implications for environmental innovation. One important caveat in our conceptualization is that we adopt a wide definition of innovation to include novelty not only in products and processes but also in policymaking styles.

## A systems-based view of transitions

A transition is a process of change through which society, or a subsystem of society, moves to a different stable state. A transition is induced through interplays of social, economic, ecological, technological and institutional developments (Rotmans, Kemp and van Asselt 2000). Transitions are evolutionary phenomena embodied in systemic processes that combine new and old elements to generate a new regime or state through a relatively rapid and sometimes chaotic process. The concept of transition thus articulated is firmly rooted in the development of complex systems (Nicolis and Prigogine 1989; Kay 1991), which holds that under certain conditions open systems will ultimately move away from equilibrium and will establish new stable structures. The development of complex systems is characterized by phases of rapid (re)organization leading to steady states, which after a period of relative calm tend to lose their stability and move toward rapid reorganization to constitute a new dynamic equilibrium.

The organization/disorganization/reorganization process that characterizes a given (sub)system may be continuous or catastrophic, but is in

both cases evolutionary in that at no time are all total system components ''stationary''. In addition, each new state has elements or remnants of past states and thus there are no entirely ''new'' states. Some steady states may be more stable than others, however. A transition is thus said to occur when a new (significantly different) dynamic equilibrium is reached (Rotmans, Kemp and van Asselt 2001). The occurrence of a transition can be traced to a series of interrelated institutional changes in and between the stable states.

Transitions occur over relatively long periods of time (twenty to thirty years or longer) and the process of change is non-linear and analogous to the development of Kay's (1991) ''thermodynamic branches'' (figure I.1). To illustrate, the path in figure I.1A depicts a subsystem that develops along a thermodynamic branch toward an ''optimum operating point'' where the organizing and disorganizing forces neutralize one another and thus stabilize. Changes in the total system can cause a movement from the stable optimum operating point to a new optimum operating point (figure I.1B, 2). This is equivalent to moving to an earlier, less stable, ''successional'' stage. In figure I.1B, the (sub)system is more volatile at point 2 than at point 1. If this new balance is further disturbed, due to additional changes in the larger system, the subsystem can move away, through a bifurcation, from the original thermodynamic branch to a new branch and onto a new optimum operating point (figure I.1C, 3). Kay (1991) refers to these transitions as ''flips'' in the subsystem.

Using similar metaphors to Kay's (1991) conceptualization and drawing on ''demographic transitions'' (Davis 1945), Rotmans, Kemp and van Asselt (2001) hypothesize that transitions consist of the following stages (see figure I.2):

(1) A pre-development phase of dynamic equilibrium where the status quo does not visibly change.
(2) A take-off phase where the process of change gets under way because the state of the system begins to shift.
(3) A breakthrough phase where visible structural changes take place through an accumulation of socio-cultural, economic, ecological and institutional changes that react to each other. During the acceleration phase, there are collective learning processes, diffusion and embedding processes.
(4) A stabilization phase where the speed of social change decreases and a new dynamic equilibrium is reached.

In the predevelopment phase, clearly defined structures, routines and repetitions characterize the subsystem and provide a certain degree of predictability of events. The onset of change is evidenced through the occurrence of unprecedented events, a weakening of existing structures and decreased repetition. ''Events'' may be significant social, environmental

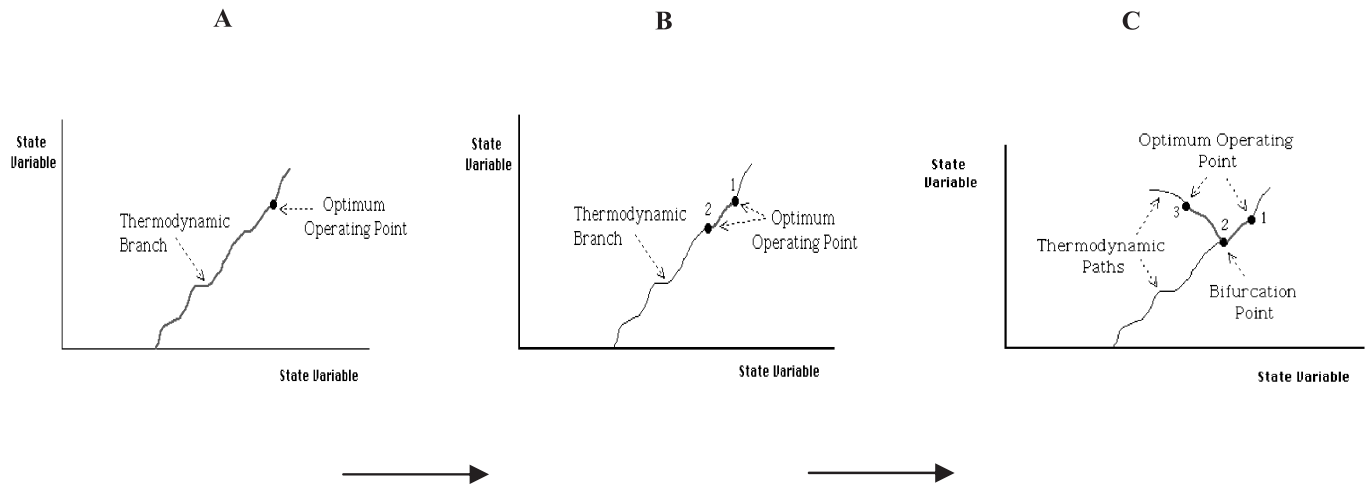


Figure I.1 Transitions from a complex system's perspective

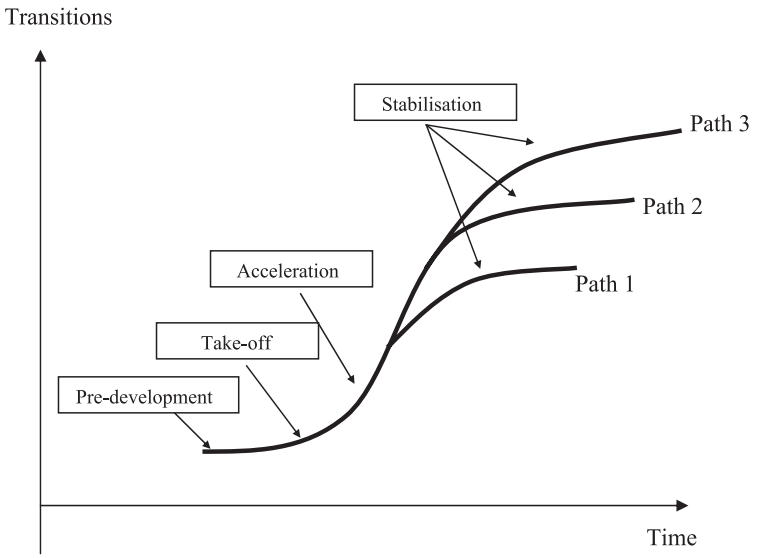


Figure I.2 Phases of transitions

and economic problems, new visions or innovation. The emergence and establishment of new structures and routines mark the beginnings of a new institutional order closely associated with a new, stable dynamic equilibrium. These phases are consistent with Kay's (1991) conceptualization of ''thermodynamic branches'' (figure 1) and Rostow's (1960) ''modernization theory''.[6]

A transition may be said to have occurred every time an optimum operating point is instituted in the subsystem. The subsystem may be an ecosystem (Kay 1991, 1994), an organization, a policy domain (Ostrom 1999; Sabatier and Jenkins-Smith 1999), a system of production and consumption, a group, a scientific discipline or a paradigm (Gersick 1991).[7] Change viewed in this light is never entirely constituted of new elements. Rather, it is a product of the processes of variation and selection in which there is heredity and recombination of technologies, ideas, practices, routines and forms. The occurrence of radical technology and its adoption by existing organizations, or the occurrence of surprises and breakdowns of existing regimes, are all events that can catalyze change and the onset of new trajectories and institutionalization processes.

Relative stability of institutional dynamics may be viewed as the optimum operating point in figure I.1C. When an event, or a set of interrelated events, forces a movement to a bifurcation point (figure I.1C, 2), stability is undermined. A new trajectory is more likely to set in when current structures are weakened. If pressure by events on the current

structures persists, in all likelihood a new trajectory will result and lead to a new optimum operating point (figure I.1C, 3). In a socioeconomic context, an optimum operating point in figure I.1 is produced through a coming together of scientific knowledge, production process technologies and practices and infrastructure. The move from one optimum operating point to the next is often the product of a co-evolutionary process characterized by the interplay between endogenous and exogenous factors. Analysing transitions and the emergence of environmental innovations requires in-depth knowledge of the endogenous and exogenous factors and the institutionalization processes that they may have set in motion. Stability at the end of a process of reorganization can be traced to specific, socially embedded bodies of knowledge and technologies, habits, norms and forms, which collectively structure economic activity. These structuring phenomena are synonymous with institutions.[8] Transitions become apparent when one compares different periods of stability through historical examination and analysis of quantitative and qualitative empirical data as illustrated in the chapters by Gunningham, Herbert-Copley, Kemp and Parto et al. in this volume.

## An institutional view of transitions

An evolutionary approach to innovation recognizes irreversible and continuing processes in time; long-run development rather than short-run marginal adjustments; variation and diversity as the fuel of all evolutionary processes of selection; non-equilibrium as well as equilibrium situations; and the possibility of error-making and non-optimizing behaviour as these are part and parcel of both human learning and evolution itself (Hodgson 1994: 223).[9] Elsewhere, Hodgson (1993: 258) echoes Nelson and Winter (1982) by pointing out that radical change may be a product of gradual change when the cumulative strain of gradual change leads to outbreaks of conflict or crisis in a stable system, resulting in a radical change in actions and attitudes. The cumulative effect of incremental or sudden change over time may culminate in gestalt shifts or ''transitions'' (Rotmans, Kemp and van Asselt 2001). A transition, or a structural change, such that the mode of production or materials' flow in the economy is fundamentally reconstituted, requires persistent external attractors and responsive internal actors over time to mould the new ''instituted process'' born of a combination of old and new institutions. As noted earlier, the concept of transition is firmly rooted in the development of complex systems.

Analysing transitions with the intent to identify the causal chain and thus the steering opportunities from a policy perspective requires adopt-

ing an evolutionary perspective and a focus on what the economic system ''ought to'' be doing. Environmental regulations have emerged as structuring phenomena to steer industrial activity away from excessive environmental damage as something that ought to be avoided or minimized. The different types of transition reported in the case studies of this volume have all taken place through ''a set of connected changes, which reinforce each other but take place in several different areas, such as technology, the economy, institutions, behaviour, culture, ecology and belief systems'' (Rotmans, Kemp and van Asselt 2001: 16). An institutionalist perspective on transitions attaches considerable weight to ''historical contingency'' that underlies the institutional functionality within a particular historical, social, political and cultural context.

An important feature of managing transitions is the development of alternative technologies and alternative ways of instituting technology.[10] It is worth pointing out that Polanyi (1957) placed great emphasis on the links between policy and technology and how policy, not process, determines alternative technology and alternative ways of instituting technology. A significant part of economic policymaking focused on innovation should thus be about determining the desirability of the technology in question, the institutionalization process(es) required to adopt the technology, and whether or not expectations of adoption and the subsequent changes are realistic – given the institutional context. The institutional context can reveal why people make the choices they do and how deeply felt beliefs or political ideology can shape choice over time. The role of ideology and other beliefs cannot be fully appreciated, however, without digging deeply into how cognitive processes evolve and how learning occurs (North 1993). Thus the frame of reference for economic actors is never a given, but created by (and for) them based on values ranging from deeply felt beliefs, e.g., religious conviction, to opinions about how best to fix a shared problem, such as air pollution. If in the assumption is one of supremacy of the market, it is likely that the ensuing analysis would focus on market ''efficiency'' rather than material sufficiency.

Transitions are often triggered by external events, such as macroeconomic crises, or shifts in consumer preferences. This is especially the case in the diffusion of ecologically sustainable technologies. The period preceding a transition is characterized by firms, customers, policymakers and other parties all claiming a stake while learning, adapting, negotiating and making compromises with regard to the changes that need to be made and the technologies adopted. In other words, the output characteristics of technologies are socially constructed. We might further conclude that this process is embedded, cumulative, path-dependent, based on changes in existing institutional textures and dependent on windows of opportunity to ''lock-in''. Each new dynamic equilibrium state has ele-

ments or remnants of past states and thus there are no entirely ''new'' states.

To illustrate, consider the case of the European pulp and paper industry where high levels of chlorine in wastewater discharge from pulp and paper mills acted as the main trigger for the technological transition that ensued (Reinstaller and Kemp 2000; Herbert-Copley, this volume). Two types of technology constituted the policy alternatives within the pulp and paper subsystem. These were: elemental chlorine-free (ECF), which removed only elemental chlorine and was the cheaper and less effective of the two technologies; and totally chlorine-free (TCF) which completely removed chlorine from the process of bleaching. During the 1990s the European pulp and paper industry largely opted for the TCF technology while the North American counterparts widely adopted the ECF. The European subsystem's environmentally superior technological transition may be attributed to the institutional dynamics that underpin the pulp and paper subsystem in Europe. An important characteristic of these dynamics is the central role played by associative institutions, e.g., environmental and non-governmental organizations including industrial associations, in influencing the perception of key actors such as consumers and government policymakers about the desirability of certain technologies.

In Europe, consumer preference played a key role in forcing the adoption of the ''cleaner'' technology, i.e., TCF, whereas the case of the United States is said to have been centrally influenced by the pulp and paper industry's vested interests resulting in the widespread adoption of the environmentally less benign ECF technology. In the case of Europe, in addition to changes in the existing and new associative institutions one could also detect changes in behavioural, cognitive, constitutive and regulative institutions (table I.1). Arguably, the deeply felt contentions surrounding the ways of doing things (behavioural institutions) in the pulp and paper production process, based on opposing value sets of environmental non-governmental organizations and industry associations (cogni-

Table I.1 Types of institution

| |
|---|
| **Behavioural Institutions:** Institutions as standardized (recognizable) social habits – manifest in activities of individuals and groups as reflections of social norms |
| **Cognitive Institutions:** Institutions as mental models and constructs or definitions – based on values and embedded in culture |
| **Associative Institutions:** Institutions as mechanisms facilitating prescribed or privileged interaction among different private and public interests |
| **Regulative Institutions:** Institutions as prescriptions and proscriptions |
| **Constitutive Institutions:** Institutions as the bounds of social relations |

Based on Parto (2005b)

tive institutions) and initiated and fought out through civic and other channels shaped by property-rights structures (constitutive institutions), resulted in a series of legislative measures (regulative institutions) that transformed interrelations at the individual, organizational and societal levels. These developments underlined new key factors (such as the integrity of the ecological system) to be considered in economic policy-making and political discourse with significant ramifications for the socio-economic, political and cultural spheres.

A second example is provided through the evolution of waste management in the Netherlands (see Parto et al., this volume). In this case two transitions seem to have occurred since around 1900. The first transition signalled a move from unregulated handling of waste to centralized systems of collection and disposal. The stabilization period for the first transition appears to have been between the 1920s and the 1960s. The second transition began in the 1970s and was to a large extent related to widespread concerns about the state of the environment. This transition was characterized by a move from centralized disposal to central management of waste and was preceded and accompanied by significant changes in production and consumption patterns. The stabilization period for the second transition seems to have commenced in the late 1970s and ended by the mid 1990s. It may be suggested that a third transition, or a period of turbulence preceding a new transition, may have started in the early 1990s. The evidence includes new European Union (EU) directives on waste management, a significant drop in the total volume of non-separated household waste from the peak 1995 level, doubts about the health effects of incinerating waste, and the ''entrepreneurial'' drive to take advantage of the weak environmental regulations in the former eastern bloc countries as cost effective alternatives to managing wastes domestically.

The evolution of waste management in the Netherlands (Parto et al., this volume), the adoption of new technologies in the pulp and paper industry (Herbert-Copley, this volume) and the ecological modernization of the Japanese chlor-alkali industry (Yarime, this volume) can be understood in terms of changes in the behaviour of agents as well as changes in the structure of the political economy. One may thus underline changes in the perception of an environmental problem (behavioural institutions), emergence of mental models about how things ''ought to'' be done (cognitive institutions), legislation on how to deal with an environmental problem (regulative institutions), changes in the behaviour of individuals, organizations, and the society in assuming the responsibly about environmental problems (behavioural and constitutive institutions), and the stratification of public and private actors through the formation of alliances and interest groups (associative institutions) ex ante and ex post in each case.[11]

Collectively, the chapters in this volume adopt a broad perspective on innovation as follows. Innovation is viewed as a social process, based on learning and occurring at multiple levels. At the firm level innovation translates into new products, processes and organizational forms. At the policy level innovation manifests as novel ways of experimentation. Innovative policymaking draws on learning from past experiences to carry out new experiments to attain broad societal goals such as pollution prevention, facilitating a shift to new technologies or nurturing additional technologies to support predetermined and desirable development trajectories. In the next section we provide an overview of the chapters and underline some of the key issues raised based on this broader view of innovation. This book is organized as follows.

## Summary of chapters

Yap et al.'s (chapter 1) opening argument is that in environmental protection, the innovation process goes beyond the firm and includes government and policy innovation and learning. This chapter's study of Taiwanese firms underlines the importance of adequate national policy, effective regulatory enforcement, and competitive pressures as catalysts for firms to move toward adopting cleaner production methods. Having placed the environment on the economic development agenda, the government of Taiwan has actively pursued the integration of industrial development and environmental protection. The Taiwanese government has managed to create the demand for environmental innovation while providing support for the industry through dissemination of research and development (R&D) findings from government-funded institutions. The government's approach to implementing environmental policy has also been innovative in its own right. One significant policy innovation is the promotion of voluntary initiatives such as ISO 14001 through regulatory and other measures, making Taiwan a country with one of the highest number of firms certified to ISO 14001.

Barton et al. (chapter 2) point out that the dynamics of environmental innovation are best understood at the sectoral level of analysis because sector studies are more likely to reveal the systemic nature of innovation and to generate generalizable findings for further research and policymaking purposes. Barton et al.'s sectoral focus is unique as it transcends national boundaries. In-depth studies of the iron and steel, leather tanning and fertilizer industries in European and several industrializing and transition economies identify industry-specific environmental problems, regulatory responses to these problems and the impact of environmental regulation on the competitiveness of each sector. The starting point in this

analysis comprises the southward move of the most polluting segments of pollution-intensive industries, decreased competitiveness of those industries in industrialized European countries, and the increased competitiveness of those same industries in less industrialized countries.

The study by Chudnovsky and López (chapter 3) focuses on the institutional and organizational factors in the diffusion of pollution prevention technologies in Argentina since the early 1990s. After experiencing major pollution problems, a series of regulations were introduced to curb industrial pollution. As with many other less developed economies, environmental regulations had limited success. This was mainly due to inadequate enforcement mechanisms and a lack of ''institutional responsibility for environmental management''. The environmental regulations were nevertheless used in closing down some of the most polluting firms and forcing other industrial firms to consider environmental management more seriously. The new regulations – coupled with trade liberalization, significant flows of foreign direct investment, and popular sentiment for environmental protection in the mid 1990s – facilitated a move into a new phase in environmental management in the Argentinean industry.

Chudnovsky and López examine this new phase through the interplay between environmental management, innovation and technological modernization activities by Argentinean firms. The findings from two surveys conducted by the authors are combined with information from secondary sources to test Porter and van der Linde's (1995) hypothesis of higher environmental standards as a catalyst for product and process innovation offsets that reduce pollution but also improve productivity through efficiencies in resource use.

Herbert-Copley (chapter 4) examines the response by the Canadian pulp and paper industry to new, stringent environmental regulations introduced in the 1990s. The introduction of the new regulations occurred at a time when the sector was being forced, due to international competitive pressures, to modernize. Using a survey of pulp and paper firms carried out in 1997, this chapter examines how the industry responded to the new regulations and the extent to which other factors shaped the course of this response. The chapter offers two ''narratives'' of the events that followed the introduction of the regulations. The first narrative points to the historically reactive approach of the Canadian pulp and paper sector to regulatory compliance to underline a needs-based, end-of-pipe oriented strategy of technology adoption rather than continual innovation in environmental management. This reactive approach is also the point of departure for the second narrative, but with an emphasis on process innovation as a result of adopting environmental technologies to address compliance issues.

Gallagher's chapter (5) provides a retrospective account of the events

in Mexico since the first liberalization policies were introduced in 1985 to develop a more integrated economy and boost the country's economic growth. In the 1990s Mexico signed to the North American Free Trade Agreement (NAFTA) and entered into the Organization for Economic Cooperation and Development (OECD). Since 1995 Mexico has negotiated over twenty other free trade agreements with other countries. The outcome of these developments has been a more integrated economy with manufacturing exports comprising close to 85% of all Mexican exports. However, the integration has been accompanied by lower than average GDP growth and less than 1% annual per capita income growth since 1985.

In the early days of NAFTA, an assumption by many environmentalists was that the most polluting industries from the north would move to Mexico and thereby export their pollution. Several studies have suggested that the main motivation for industrial firms to move operations from Canada or the United States to Mexico is labour cost minimization. Gallagher points out that Mexico's regulations on pollution prevention are modelled on the United States' regulatory system. The key difference in Mexico is laxness in the enforcement of environmental regulations, making pollution a ''bonus'' for the environmentally callous industrial firm.

The Mexican government's policy on economic integration has not resulted in technological innovation, or improvements in environmental protection, as had been hoped. In fact, like most developing countries Mexico prioritized economic integration and growth at the expense of environmental protection on the implicit assumption that once a certain level of per capita income has been reached, environmental problems could be more effectively addressed. In 1985 Mexico had a per capita income of US$5,000. With the liberalization policies that ensued from 1985 onwards, there have been only small rises in per capita income while there has been significant environmental degradation. Paradoxically, the financial costs of environmental damage and degradation are estimated at 10% of the GDP from 1988 to 1999, an amount that far exceeds the 2.5% average rate of economic growth.

Adeoti's point of departure (chapter 6) is to question the wisdom of the view held by some economists that environmental policy is the main driver for industrial innovation. Based on an analysis of case study data from Nigerian food processing and textile firms, Adeoti identifies a number of ''third-party factors'' as key determinants of environmental innovation, in addition to firm-level environmental policy and the regulatory framework. He also points to the importance of existing structures and the institutional context for successful environmental policy development and implementation conducive to environmental innovation. The third-

party factors are the combination of influences on polluting firms from such sources as host communities, public corporations affected by private sector pollution, ENGOs, parent company requirements and environmental technology suppliers. A key insight in Adeoti's analysis is that to have maximum effect, environmental regulations have to be designed in recognition of the capacity of affected firms to adapt, economically and technologically.

The capacity for compliance to stringent regulations and to innovate in environmental protection is the main theme of Yarime's analysis (chapter 7). Yarime examines the co-evolution of the Japanese chlor-alkali industry and its regulatory arena since the 1950s. The Japanese government introduced stringent environmental regulations in the 1970s to stop the mercury contamination traced to the chlor-alkali industry. In a top-down manner, a newly appointed Countermeasures Council demanded that the industry install a closed effluent system to contain mercury by the end of 1974. The council also specified the diaphragm process – the only available technology at the time – as the technology to be adopted by the industry. Faced with strong opposition from the industry on the grounds that there were many unresolved technical and economic issues, the government agency moved the date to 1975 for the majority of operations and made a concession to the laggards to install a closed effluent system by March 1978.

Given the tight timetable for the majority of the firms in the sector, many had to imitate rather than innovate to convert their processes and meet regulatory requirements. Once adopted, the diaphragm process turned out to be expensive and produced inferior quality product. Energy consumption of the diaphragm process was significantly higher than the mercury process. At first the government attempted to compensate for the weakened competitive position of the converted firms by organizing a barter system and guaranteed product sales. Sharp rises in energy prices put additional pressures on converted plants leading to additional production costs. This prompted the government to provide compensation to the modified firms by financially penalizing the mercury process firms. The government objective of safeguarding public health and the industry's concern about costs and loss of market share due to inferior quality were clearly not being resolved adequately. A new technology was needed to bring about this resolution and a new approach to policy making had to be adopted.

Gunningham (chapter 8) recognizes the limitations of the command-and-control approach to environmental policymaking, but cautions against dismissing regulations as unnecessary obstacles to economic efficiency as argued by a large number of economists and other commentators. He also recognizes that since the beginning of the 1990s regulatory

regimes in general have suffered from shrinking resources, particularly in terms of enforcement. In addition, much of the low-hanging fruit has been picked already, rendering the ''first-generation regulations'' blunt as tools to achieve economically viable and lasting environmental benefits. The answer according to Gunningham lies in nurturing environmental innovation through ''second-generation'' regulations, which still require a central but selective role for government but also draw on a range of market and non-market solutions. Gunningham then proceeds to evaluate the main instruments for second-generation regulations, including self- and co-regulation, voluntary agreements, economic incentives, informational regulation, performance- and process-based standards, and regulatory flexibility against empirical findings from a study of the pulp and paper sector in multiple national settings.

Parto et al. (chapter 9) begin with a brief overview of the evolution of the waste arena (''subsystem'') in the Netherlands since the mid-nineteenth century. The notion of ''transitions'' is reconceptualized from a systems perspective in an attempt to represent transitions as more than just a tool for retrospective analysis of past events. Parto et al. state that through historical overviews it is often possible to point to a certain set of developments or events as having constituted a transition. However, policymaking aimed at facilitating transitions requires rather more than retrospective overviews and intuitions on what has already occurred. As well as documenting and understanding how transitions may have occurred, Parto et al. underline the importance of identifying the structural and other factors that lead to transitions. These factors include formal and informal institutions, significant events (including innovations and societal problems) and the processes of institutionalization set in motion by these events.

The authors view institutions as structuring phenomena in transitions and transition analysis. Institutions are defined as multifaceted; durable but evolving social structures made up of symbolic elements, social activities and (sometimes) material resources. Institutions weave together social, economic, environmental and political systems or ''spheres''. Institutions collectively shape interactions and transactions among economic agents and are manifest at different levels of interrelation and territorial scales of governance. The policy implications (for transition management) of this view of institutions is that to facilitate transitions policymakers need to know what degree of control may be exercised over specific key factors, given the institutional context. To identify and to take advantage of context-steering opportunities, a policymaking arena or subsystem needs to be viewed as a constellation of problems, policies and politics. This constellation can explain when, how and most importantly why significant changes occurred in the subsystem over time.

The chapter by Kemp (10) examines the effectiveness of innovation policies and environmental policy in bringing forth environmental innovations – innovations offering environmental gains relative to existing technologies. Kemp argues that innovation policy is insufficiently oriented toward broader sustainability goals, while environmental policy hardly acts as a pull for innovation to lead to the emergence of new products and processes with environmental benefit. The chapter makes suggestions on how to narrow this gap through ''transition management'', described as being concerned with altering social trajectories through innovative and interactive policy-making. In transition management the emphasis is placed on process management so as to nurture not one, but a set of preferred options leading to environmentally superior outcomes. Transition management has been adopted by the Dutch government as a steering model for working toward sustainable energy, mobility and agriculture. To make a case for transition management, Kemp examines and compares the German BMBF (Bundesministerium für Bildung und Forschung – German ministry for education and research), the Dutch DTO (Defensie Telematica Organisatie – sustainable technological development) and the Danish Clean Technology Development programmes. These programmes were funded by the three national governments to induce innovation in environmental technologies. The comparison reveals different styles of interaction between policy makers and industry. The Danish programme appears to have had the highest element of mutual learning – having yielded the highest environmental benefits – followed by the German programme. The Dutch programme was successful in yielding environmental innovation but had little impact on policy learning. Drawing on these three cases, Kemp argues that in transition management there is an integrated innovation policy for the environment, supported by programmes that go beyond providing research funding.

In most countries, environmental and innovation policies are not fully or adequately integrated. Yet, it is widely accepted that there is constant interplay between innovation, environmental protection and further innovation. Given that numerous countries, particularly in the north, have at least a formal environmental policy and an innovation policy, it is only the next logical step to attempt to integrate the objectives of the two policies. Innovation policy can be more explicitly directed toward environmental protection by providing support for R&D in the development of environmental technologies, e.g., fuel cells as an alternative to the combustion engine to power vehicles. Environmental innovations such as fuel cells could become economical and institutionalized through regulation and other incentives that steer vehicle makers and users away from gasoline and diesel toward fuel from renewable sources. In managing a tran-

sition to a more sustainable technological trajectory, innovation policy on transportation should not focus only on fuel cells but promote a series of more sustainable alternatives, leaving the choice of the fittest alternative technology to the variation/selection process as articulated under ''transition management''[12] or as illustrated through the various case studies by the authors contributing to this volume.

The concluding chapter (11) provides a synthesis of the case studies followed by some broad insights into the interplay between environmental regulation, innovation as a process and a policy objective, and the implications for integrated policymaking geared toward better protection of the environment and improved economic performance.

## Notes

1. See, for example, Gibson, R. B. (1999). Voluntary Initiatives: The new politics of corporate greening (Peterborough, Ont.: Broadview Press).
2. See, for example, Welford and Starkey (1996) for a selection of the arguments for and against.
3. The oft-cited case example is 3M which reportedly has saved close to $800 million since 1970 through implementing its ambitious ''Pollution Prevention Pays'' programme.
4. See Welford and Starkey (1996).
5. For more information on ecological modernization theory we refer the reader to Hajer (1995) Jänicke (1991), Mol (2001) and Spaargaren, Mol and Buttel (2000).
6. Rostow (1960) describes economic development as the passage of society through five evolutionary stages: traditional society, the stage of the preconditions for take-off, the take-off stage, the drive to maturity and the age of high consumption as exemplified by modern industrialized states.
7. The metaphors and examples drawn from biology and ecology are used here insofar as they deepen appreciation and understanding of socioeconomic complexities. This selective utilization of other disciplines is consistent with Nelson and Winter's (1982: 11) ''Lamarchian'' approach.
8. See Parto (2005a) for elaboration and further discussion.
9. This section is based on Parto (2005a).
10. Technology, defined as ''the combination of tools, skills, and knowledge ... organized as the industrial arts of a society... [whose] change stimulates creation of new social relationships and thus a new society'', is the most emphasized aspect of policymaking in the institutionalist literature (Hayden 1993: 291).
11. See Parto et al. (this volume) and Parto (2005b) for more elaborate discussions of waste management in the Netherlands.
12. See Kemp, this volume, and Parto et al., this volume.

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# Industrial Innovation and Environmental Regulation: Developing Workable Solutions

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What role should governments play in protecting the environment and controlling the environmental impacts of industry? Do regulations benefit the environment, and how do they affect industrial innovation?

Since the modern era of environmental management began in the early 1970s, regulations have been used with increasing intensity and sophistication as the main instrument in steering the behaviour of economic agents in industrial production. The purpose of environmental regulation has been to coerce producers of goods and services into internalizing the environmental costs of production. These efforts have often faced opposition on practical and ideological grounds.

Since the 1980s there has been a movement towards liberalization, coupled with the continued failure of the market to protect the environment as a public good. As a result, private and public sector interests have been engaged in debate about the apporpriate role of governments in protecting and improving the environment and controlling the environmental impact of industry.

The contributors to this book examine a number of political and industrial trends and responses to these challenges. A useful set of case studies appraise environmental policies and comprehensive statements on environmental protection and sustainable development by numerous countries in the North and the South.

The book concludes that the complexities of environmental and economic relationships disallow universal solutions, and it illustrates the need for context-specific and non-linear perspectives on the role of regulatory measures in environmental innovation.

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