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## **Embedded autonomy and ecological modernisation in Taiwan**

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**Abstract:** This paper aims to study the progression of Taiwan's environmental reform and how the political economy and social institutions affect this process. With its unique political economy structure, namely the embedded autonomy, Taiwan's environmental reforms may provide a valuable empirical contribution to Ecological Modernisation Theory (EMT) debates. Key questions addressed in this study are: First, the extent to which environmental reform is taking place in Taiwan in general, and in high-tech industries in particular, and what mechanisms bring about the reforms. Second, the extent to which EMT concepts are applicable in evaluating and shaping Taiwan's environmental protection efforts. Data were collected from public documents and interviews with government and industry leaders. This study concludes that ecological modernisation is taking place in Taiwan, especially in the high-tech sector, led by state technical and economic agents. Embedded social network relationships between the State and firms assist firms in taking the path of ecological modernisation.

**Keywords:** ecological modernisation; Taiwan environmental policy; high-tech industries; newly industrialising country; developmental state; embedded autonomy; sustainable development; environmental management; environmental movement.

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## **1 Introduction**

In the late 1980s, there was a significant shift in the character of environmental crises, from intrinsically local issues to global issues, such as global warming and ozone depletion. Corresponding to such a shift, there has been a renewed interest in environmental issues among the general public, policy makers, environmentalists, academics, and business decision makers. This new wave of the environmental movement embraced policy innovations (e.g., market-incentive environmental regulations), technological innovation (e.g., industrial ecology, life-cycle analysis, environmental management and ISO 14000), and pervasive public discourse (e.g., sustainable development). Against this backdrop, Ecological Modernisation Theory (EMT) emerged in Europe, as a social change theory, devoted to conceptualisation of these institutional changes pertaining to environmental problems and solutions.

Ecological modernisation theory distinguishes itself from a critical approach, and suggests fundamental and constructive roles that science, technology, capital and the state can play in the process of environmental improvements. Its central thrust is that environmental problems have been caused by modernisation and industrialisation, and that their solutions must necessarily lie in modernisation and 'superindustrialisation' rather than de-industrialisation. Emerging from the context of European industrial advanced societies, EMT witnesses institutional transformation in the process – radical restructuring of production, consumption, state practices, and political discourses along ecological rationality (Mol, 1995; Hajer, 1995). However, as Buttel (1999) has argued, due to the fact that the development imperatives, the political culture, the state structure, and the social institutions differ across countries, the environmentalism, its mechanisms, and the institutions that back up environmental policies or environmental reforms differ accordingly. Consequently, the legitimacy of EMT in explaining environmental reforms in less industrialised countries and newly industrialising countries becomes a contested question.

This paper contributes to the discussion of EMT by examining the usefulness of EMT concepts for evaluating and shaping environmental improvements in newly industrialising countries, taking as one case Taiwan; specifically Taiwan's high-tech industries. High-tech industries are the most globalised, innovative, and strategically important industries in Taiwan's economic development plans. Hence, we are most likely to detect ecological modernisation in Taiwan's high-tech industries if ecological modernisation is happening in Taiwan at all. Further, the latest competitive shift in the Taiwanese industrial structure has been away from high-pollution intensities toward low-pollution intensities, and high-tech industries are promoted under the statute for environmental consideration. The nexus between the state and high-tech industries manifested itself as the best social institution for understanding the specific dynamics of environmental reforms.

Taiwan is known, in political economy literature, as a developmental state, in which the state plays a leading role in planning and prioritising economic development in the process of industrialisation. The rapid economic development track that Taiwan has been able to stay on drew many scholars' interests in studying the effectiveness of Taiwan's economic structure and the synergy between the state and the market, i.e., the embedded autonomy (Evans, 1995, 1997). Given its unique economic development experiences and state-economic structure, Taiwan's environmental reforms, particularly economic and environmental development in high-tech industries, could provide a valuable empirical

contribution to EMT debates. This paper examines Taiwan's ecological modernisation process and dedicates the results to the global project of building EMT.

### *1.1 Purpose of the research*

Two main questions are addressed in this study:

- the extent to which environmental reform is taking place in Taiwan in general and in high-tech industries in particular, and what mechanisms bring about the reforms
- using EMT as a theoretical perspective, the author intends to contribute to the theoretical discussion of EMT by examining the usefulness of EMT concepts for evaluation and shaping environmental protection efforts in newly industrialising countries – specifically Taiwan's high-tech sector.

In the next section, the framework of EMT will be summarised to aid our analysis. In Section 3, an overview of Taiwan's environmentally related institutional changes will be provided, the role social agents play in this transformation will be discussed, and the extent to which these changes cause ecological concern will be addressed. In Section 4, the role which the State plays in the development of high-tech industry is detailed, followed by how this relationship of embedded autonomy between the State and high-tech industries facilitates the implementation of environmental policy. This paper will conclude with discussions, in terms of the social, political, and economic spheres of EMT, on the trends and challenges of economic transition and ecological modernisation in Taiwan.

## **2 Research framework**

For the purpose of examining the applicability of EMT in Taiwan's environmental reform efforts, it is necessary to identify the key characteristics of EMT. In the early development of EMT, scholars emphasised the technical aspect of environmental improvement in the process of production and in the conservation of material (Janicke et al., 1989; Hajer, 1995). Clean technology, recycling, waste reduction, dematerialisation and renewable resources are identified as the path toward clean production. Another focus for EMT scholars has been identifying the institutional and social aspect of environmental transformation. Mol et al. suggest (Mol, 1995; Spaargaren, 1997; Sonnenfeld, 2000) a few significant institutional characteristics for ecological restructuring in Western Europe. The State regulatory structure has shifted from centralised top-down management to decentralised participatory negotiation management. Regarding environmental policy, the roles that non-governmental organisational play has moved from outside to inside environmental policy networks, and direct interaction between business and NGOs has become a new trend. A summary of institutional characteristics is provided in Table 1. In addition to the technical and institutional aspects of ecological modernisation, a third focus of EMT has been on mechanisms of change. Two mechanisms are seen as operative. The first mechanism, 'economising the ecology,' fosters internalising of previously externalised costs by ascribing monetary value to natural resources. The second mechanism,

‘ecologising the economy,’ embeds the economy into ecology, and incorporates knowledge of natural cycles into economic activity.

This study is thus going to look at clean production technology, institutional transformation, and the mechanism of environmental reform to examine the fit of EMT with Taiwan’s environmental reform.

**Table 1** Institutional transformation for ecological modernisation

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Science and technology are not only causes of environmental problems but also valuable and potential sources of solutions
Market dynamics and economic agents are not just the disruptive force of ecological degradation, but are the carriers of ecological restructuring and reform
The role the nation-state plays in environmental reform has changed from top-down, centralised command and control environmental regulation to more decentralised, flexible and consensual styles of governance
Social movements are more engaged in public and private decision-making institutions regarding environmental reform rather than merely protesting
There are changing discursive practices and emerging new ideologies regarding environmentalism with a vision of sustainability

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*Source:* Ecological Modernisation Theory

### **3 An overview of Taiwan’s environmental reforms**

#### *3.1 The emergence of environmentalism*

The emergence of environmental awareness has its own roots in the reaction to the outbreak of environmental harms (Hsiao et al., 1995). Hsiao (1999, p.32), based on his four previous national studies (1982, 1986, 1989, 1991) on public awareness of Taiwan’s environmental problems, argues that Taiwan’s environmental movements and politics can be characterised by three distinctive streams: the anti-pollution protests, dating from 1980; the nature conservation movement begun in 1982; and the anti-nuclear movement which started in 1988. Anti-pollution has awakened Taiwan’s environmentalism awareness since 1980, and it has continually been the major collective action pertaining to environmental protection. Anti-pollution protests were mostly mobilised against, or sought compensation for, past injuries or losses to residents. The movement was reactive rather than preventive or preemptive. Preventive or preemptive protests accounted for only 16% of the 1,211 local anti-pollution protests that took place between 1980 and 1996. As Hsiao (1997a) argues, this stream, the dominant one, of Taiwan’s environmentalism can be characterised as victim activism.

In the early stages, Taiwan’s political institutions disadvantaged the development of an environmental movement. Under the one National Party rule, all kinds of social movements confronted substantial difficulties in mobilising social resources to draw on appropriate support and to legitimise their actions. However, as a result of political liberalisation, educational pervasiveness and advancement, and the development of mass media since the 1980s, the environmental movement has been able to attract more attention from the general public and stimulate greater environmental awareness. In particular, after the lifting of martial law and other long-time political bans in 1987,

the frequency of environmental protests increased significantly. According to Hsiao (1997b), of the anti-pollution protests that occurred between 1980 and 1996, over 90% of 1,211 recorded disputes took place between 1988 and 1996.

Besides the occurrence of quantitative changes in environmentalism in Taiwan, there have been gradual qualitative changes. In the past decade, the scope of environmental awareness in Taiwan has no longer been limited to the issues of environmental protection and ecology preservation at the local level. Instead, it has been enlarged and participates in the global discourse regarding issues of sustainable development, including global warming, biodiversity, and environmental justice. Those involved in environmental movements are coming from more social classes, from local victims to scholars, writers, students, scientists, aboriginals, and politicians.

### *3.2 Democratisation and the proliferation of NGOs*

Some environmental literature presumes that democratisation is a prerequisite condition for the progress of environmentalism. However, it is a contested question in the case of Taiwan. It is noted that the early development of environmental movements and other social movements have brought in the democratisation processes as a result of their efforts. The rapid increase in environmental protests in Taiwan reflects not only a direct response to the deteriorating living environment and ecosystem, but also an activist culture that encouraged people to take direct action to solve society's environmental problems during the political liberalisation period of Taiwan (Yang and Lin, 2000). In the early 1980s, labour, farmers, women, and student movements, either based on sympathy or strategic concerns, came into coalition with one another to mobilise necessary social resources in order to challenge the long-standing authoritarian state. We could easily find overlap of leadership in these social movements. These coalitions promulgated the proliferation of non-governmental organisations in Taiwan, especially after 1987.

These organised civil groups play significant roles in the development and evolution of Taiwan's environmental movement. By one estimate there were over 232 environmental NGOs in Taiwan (Hsiao, 1997b). Major groups including the Taiwan Environmental Protection Union (TEPU), the Taiwan Greenpeace Association,<sup>2</sup> the Ecological Conservation Alliance, the Wildbird Society, the Homemaker's Union and Environmental Protection Foundation, the Life Conservationist Association, and the Chung-Hua County Pollution Control Association, were actively attempting to participate in and influence environmental policy-making locally and nationally, largely through demonstrations, elections, coalitions, and information (Lin, 1995). Interestingly, there have been no international environmental NGOs established in Taiwan. While violence has occasionally occurred at environmental protests, there was no evidence showing that environmental NGOs in Taiwan have intentionally adopted 'violence' as a tactic to influence decision-making. Although these organisations do not define the entirety of the environmental movement, they are clearly the most visible and often the most influential actors in environmental policy debates, as well as the catalysts for the construction of environmental awareness in Taiwan (Yang and Lin, 2000).

Although Taiwan's environmental NGOs have grown in number, difficulties in recruiting members and looking for financial support have also emerged. Another weakness that Taiwan's environmental NGOs have shown is a lack of information resources from international environmental NGOs. In order to connect with international

environmental NGOs, Taiwanese environmental groups need to be provided with sophisticated environmental knowledge to handle high-tech environmental problems.

### *3.3 The industrial structure and the environment*

Rapid industrialisation and modernisation have long been blamed for the ecological devastation in contemporary societies. With a double-digit growth rate in economic development over the past thirty years, Taiwan's 'miracle economy' has brought material wealth to its people, but in the process created ecological hardships for the island. As the public became more aware of the high environmental risks incurred by rapid economic development, business became more aware of the environmental costs incurred as a result of rigid environmental regulations, and the government was frequently confronted with environmental management challenges. At the same time, as the world's 13th largest trading economy, Taiwan also experienced structural change in its economic sectors. The production value of the industrial sector grew from 19.7% in 1952 to 47.1% of Taiwan's GDP in 1986, and then gradually dropped to 27.7% in 1997; while the agricultural sector shrank from 32.2% to 2.7% during the same period. Meanwhile, the production index of the heavy chemical industry increased 2.3-fold from 1987 to 1997 (CEPD, 1999). This changing industrial structure carries considerable implications for environment policy and resource uses in Taiwan.

### *3.4 Structural embeddedness of environmental problems: the developmental state, embedded autonomy, and flexible capitalism*

In political economy literature, Taiwan's developmental experience has been widely regarded as the typical model of a 'developmental state' (Amsden, 1985; Deyo, 1987; Wade, 1990). This refers to states that embrace economic development as the foremost goal of state action, and play a leading role in the process of capital accumulation. The role of the State in promoting economic growth is to guide the direction of the economy through selective State intervention, State industrial planning and development strategies and policies. As Castells points out,

"The core of Taiwanese economic growth lies in the notion of flexible production ... The flexibility concerns both the industrial structure itself, and the adaptability of the overall structure to the changing conditions of the world economy, under the guidance of an all-powerful state ..." (Castells, 1992, p.41)

In fact, the core of such 'flexible capitalism' lies in the Kaomintang (KMT) state and the highly diversified networking relationships among business groups, between the State and business, and between businesses and the world economic system (Castells, 1992, p.42). This 'flexible capitalism' has constructed an important dimension of Taiwan's ecological crisis – uneven development and environmental pollution. The companies with close ties to the State are prone to use such relationships to resolve environmental disputes instead of taking up some corrective action. The misuse of such State–business relationships is prevalent.

### *3.5 Institutional change in State economic development plans: away from traditional energy-intensive, and toward high-tech industries*

Chemical, petrochemical, paper and pulp factories, and steel mills are perceived to be the most polluting and energy-intensive industries. These energy-intensive industries accounted for approximately one-third of Taiwan's total energy consumption, while contributing only 6.69% of GDP in 1997 (Wang, 1998). It has been argued that inadequate industrial structure and energy policies resulted in serious environmental pollution and increased CO<sub>2</sub> emissions in Taiwan. The idea to shift the industrial structure toward a high-tech, less-polluting, information-based economy was becoming the consensus among policy makers and environmentalists (MOEA, 1999; Wang, 1998).

Since the 1980s, the State of Taiwan has begun to focus on the strategic development of high-tech, high value-added, and energy-efficient industries. The establishment of the Hsinchu Science-based Industrial Park (HSIP) in 1980, administered by the National Science Council, was a case in point. Through tax credit and investment benefits, businesses were encouraged to intensify research and development to enhance competitiveness in the world economy. By 1990, high-tech products, mainly electronics, information and machinery products, accounted for 40.2% of total exports. In 1991, based on the Six-Year National Development Plan, ten emerging high-tech industries, including semiconductors, communications, pollution control and treatment industries, etc., were selected as development goals for the next phase of Taiwan's development. It was expected that the proportion of the technology-intensive industries in overall production would increase to 40% by the year 2002 (IDB, 1998). Six selection principles for the ten emerging industries were:

- great market potential
- high linkage with other industries
- high added value
- advanced technical level
- low pollution
- less dependence on energy supplies (IDB, 1998).

Environmental consideration had begun to be integrated into economic plans and industrial policy.

### *3.6 High-tech industries and the environment*

Environmental problems within the semiconductor industry in Taiwan were not well documented until 1997. Previously the high-tech industry presented a clean and non-polluting image, free from environmental and occupational hazards. Then, a fire accident at United Integrated Circuits sounded the alarm that there were potential environmental risks that accompany high-tech industries. People witnessed a huge amount of chemicals and toxic materials being emitted into the air, and serious safety and environmental concerns about the semiconductor industry caught people's attention for the first time in Taiwan (Yang and Lin, 2000). The environmental risk in the semiconductor industry is not readily resolved by end-of-pipe pollution control measures. It is not widely known that the semiconductor industry uses a variety of highly toxic

materials in the process of production during cutting, polishing, dicing, and packaging. Also, the semiconductor industry changes its processes, chemicals, and technologies rapidly to enhance its global competitiveness so that the process of manufacturing is difficult to understand fully. In addition to the material hazards, the character of high energy and high water consumption in the semiconductor manufacturing process has also raised environmental impact concerns.

**Table 2** Demand for water, electricity and land for integrated circuits production by 2010

	1995	2000	2005	2010
IC production value (100 million NT\$)	1,000	11,600	23,200	35,000
Water (CMD)	22,000	255,200	510,400	770,000
Electricity (KW)	112,000			1,400,000
Land (hectare)	36.8	427	854	1,288

Source: IDB statistics (1996)

### 3.7 *Environmental policy and the regulatory framework*

Given the growing environmental pressure, Taiwan’s government was forced to react to environmental movements initiated by local civil society and the international community. In response to local anti-pollution protests, tougher pollution controls were adopted. For instance, a specific Pollution Disputes Resolution Law was passed, the Environmental Impacts Assessment Act was enacted, and other environmental protection laws were passed. Historically speaking, the environmental regulatory framework began forming in the 1970s and has developed rapidly since 1987, when the Taiwan Environmental Protection Administration (Taiwan EPA) was established under the Executive Yuan. The Taiwan government passed its first comprehensive environmental policy plan, *Guidelines for Environmental Policy at the Current Stage*, in October 1987, shortly after the Lukang residents’ campaign against government approval for a titanium dioxide plant to be built by Dupont in their community (Yang and Lin, 2000).

The administrative authority was comparatively weak in the Taiwan government. The weakness of administrative authority in the Taiwan EPA mainly results from the fact that the tasks of managing Taiwan’s environmental affairs are distributed among various jurisdictions of governmental departments and agencies. Environmental affairs are divided into two major regulatory and administration systems: pollution control and regulation on the one hand, and natural resource management on the other (Chiou, 1995). Responsibilities for natural resources management and environmental protection are distributed among several central governmental departments and agencies, such as the Ministry of the Interior (national parks services and land uses), the Council of Agriculture (forest, natural conservation and wildlife protection), and the Atomic Energy Council (nuclear power regulation and radiation protection). In contrast, the major responsibilities for the Taiwan EPA are environmental pollution control, setting standards, and enforcement. The barrier to communicating and coordinating environmental affairs among governmental agents casts a long shadow on the prospect of Taiwan’s environmental management.

Currently more than 106 laws and regulations have been promulgated, covering air, water, noise, soil and groundwater pollution, recycling, solid and hazardous waste, and



public nuisance disputes. Legislation is pending in the areas of marine pollution control and the Environmental Protection Basic Act, which was regarded as the 'environmental constitution' of Taiwan. Environmental and ecological protection is written into the Constitution as deserving priority and effort equal to economic and technological development. The high prioritisation of environmental projects in the Six-Year Development Plan, the Industrial Development Bureau's (IDB) five-year environmental improvement plan, and the Taiwan EPA's National Environmental Protection Plan have all attested to putting teeth in the environmental regulations and building capacity on the island to deal with environmental problems.

The Environmental Impact Assessment Act of 1994 is the most important environmental legislation and includes more participatory procedures for citizens and environmental interest groups. Environmental impact assessment is required for all major development projects. The Act requires that the authorities establish a review committee and that not less than two thirds of it should be composed of scholars and environmental professionals, and gives the Taiwan EPA the right to veto projects that have an adverse impact on the environment.

Overall, Taiwan's environmental regulatory framework has shifted from low-level regulation in the 1970s (Huang, 1994), via the command-and-control strategy of the 1980s, to an array of market-oriented systems. The Taiwan EPA has initiated permit systems for air and water effluents. The system will eventually track 17,999 stationary sources of air pollution and 12,000 point sources of industrial wastewater. Air pollution control fees were also introduced in 1997.

The air pollution emission standards for the semiconductor industry were announced in 1999. These standards, which are based upon emission quantities and reduction amounts, have been effective since July 1, 2000. The new standards define and cover the semiconductor industry comprising integrated circuit wafer manufacturers, wafer packaging firms, wafer-stacking companies, semiconductor masking firms, and circuit frame manufacturers. Targeted pollutants include volatile organic compounds (VOCs), trichloroethylene, nitric acid, hydrochloric acid, phosphoric acid, hydrofluoric acid, and sulfuric acid.

According to the Taiwan EPA, semiconductor firms consumed 11,500 tons<sup>3</sup> of VOCs annually, including benzene, methylbenzene, isopropyl alcohol, dichloroethylene, and trichloroethylene, resulting in approximate 3,000 tons of emission per year. The new regulation requires VOC emissions to be reduced by 90%. In addition, about 600 tons of inorganic acids were emitted each year by the semiconductor industry, which current environmental regulations have not yet effectively controlled.

**Table 3** Air pollution control standards for semiconductor industry

<i>Air pollutants</i>	<i>Emission standards</i>
VOCs	Emission reductions greater than 90% or total factory emissions less than 0.6 kg/hour (according to methane calculation basis)
Trichloroethylene	Emission reductions greater than 90% or total factory emissions less than 0.02 kg/hour
Nitric acid, hydrochloric acid, phosphoric acid, HF acid	Emission reductions greater than 95% or total factory emissions less than 0.6 kg/hour
Sulfuric acid	Emission reductions greater than 95% or total factory emissions less than 0.1 kg/hour

*Source:* EPA (1999)

Under the above-mentioned increasingly sophisticated environmental policy, Taiwan's environment has seen some visible improvements. For instance, Taiwan's government intended to comply with the Montreal Protocol in 1989 and began limiting the import of CFCs, which were widely used by the electronics industry, and joined the efforts of local industrial, academic, and research sectors in searching for CFC alternatives. These efforts resulted in reducing CFC consumption in Taiwan from 10,159 tons in 1986 to 2,493 tons in 1995, a 75% reduction over 1986's baseline consumption. This figure has continued to drop since then. Taiwan's electronic industry has adopted CFC alternative technologies, such as HCFCs, no-clean, aqueous, and semi-aqueous processes.

Taiwan also achieved notable results in its air pollutant emission reduction efforts. According to the Taiwan EPA, statistically, even though the 'natural growth emission'<sup>4</sup> is around 5–10% in Taiwan, total pollution emission has decreased for most air pollutants according to annual trends of air pollutant emissions. During the period 1991 to 1998, measured levels of PM10 were reduced from 389,000 tons to 288,000 tons, a 26% reduction. In the same period, SOx was reduced from 604,000 tons to 374,000 tons, a 38% reduction; NOx was reduced from 517,000 tons to 486,000 tons, a 6% reduction; HC was reduced from 946,000 tons to 810,000 ton, a 16% reduction; CO was reduced from 3,102,000 tones to 1,826,000 tons, a 41% reduction; Pb was reduced from 591 tons to 261 tons, a 56% reduction. The emission reduction shows that State-promoted air pollution control strategies, including emission standards, pollution behaviour control, and economic-incentives, have been successfully implemented.

In the preliminary stage of the EPA's establishment, 1987–1991, the percentage of unhealthy air quality station days was about 16%. After the Air Pollution Control Act was enacted in 1992, the EPA has actively promoted pollution control methods for industries and vehicles.<sup>5</sup> In 1997, the percentage of unhealthy air quality station days was reduced to 5.46%.<sup>6</sup> In 1998, the percentage of unhealthy air quality station days was further reduced to 5.09%. And according to the stipulated targets of the National Environment Protection Plan, the percentage of unhealthy air quality station days will be reduced to 3% in 2001, 2% in 2006, and 1.5% in 2011 (EPA, 2002).

In addition to air quality improvement, water quality improvement has also been effective. In 1999, 0.37% of the total tap water samples taken were found to be below minimum quality requirements, compared to 0.41% in 1998, 0.9% in 1997, and 2.95% in 1996.<sup>7</sup>

### *3.8 State-assisted environmental management*

Although environmental groups were critical of the environmental regulations and standards set out by the Taiwan EPA, many companies began to invest in environmental pollution equipment and improve processes for cleaner production. The Taiwan EPA, the IDB and the Industrial Technology Research Institute (ITRI) have been leading and developing programs to assist companies in establishing environmental management systems. Through the amendments to the Statute for Encouragement of Investment, tax credit and investment incentives were provided to industry for improving pollution control, energy efficiency and conservation, recycling, and waste reduction. For example, manufacturers are eligible for 5–20% of company tax credit for expenditure on environmental protection equipment or energy conservation technology. Anti-pollution investment plans, or construction projects qualify for low-interest loans. An Industrial Pollution Prevention Technology Advisory Task Force was also established by IDB to

assist industries to reduce pollution and minimise waste in the most cost-effective manner.

For both economic and industry safety concerns, many of the semiconductor companies in HSIP are making efforts to address environmental issues. It was estimated that over 50% of the companies in HSIP have been ISO 14000 certified, including the leading semiconductor companies in Taiwan, United Microelectronics Corporation (UMC), Taiwan Semiconductor Manufacturing Company, and Winbond Electronics. For UMC alone, its investment in pollution control equipment exceeded NTD 50 million in 1999. It is estimated that environmental practices and resource conservation resulted in economic benefits of NTD 537 million (UMC, 2000).

In short, State-assisted environmental management has characterised the industrial and environmental policies in Taiwan. With policy goals of maintaining sustainable economic growth, improving living standards, and protecting the environment, the State has not only assisted firms to make structural adjustments and accelerate upgrading to cleaner production, but has also adjusted industrial structure and the trajectory of technical modernisation.

The following section explains how the embedded autonomy relationship between the State and high-tech industries facilitates the implementation of environmental policy.

## **4 Taiwan high-tech industries**

### *4.1 The role of the state in developing high-tech industries*

The state's involvement in the development of the semiconductor industry is considered vital for success. In the 1970s, when the semiconductor industry was in its infancy, requiring intensive capital investment for its research and development, the state's incubating role became critical in providing technical,<sup>8</sup> financial, and institutional support for its success. For building semiconductor industries in Taiwan, the Industrial Technology Research Institute (ITRI) and the Electronic Research Service Organisation (ERSO) were established as main institutions to cultivate the technologies, rapidly diffuse technologies, and give birth to the semiconductor industry. Major private firms such as the United Micro Electronics Corporation, and the Taiwan Semiconductor Manufacturing Company were created directly under the State's sponsorship. The State provides virtually everything needed for the formation of major semiconductor manufacturing firms, including capital investment, technology transfer and manpower (Mathews and Cho, 2000).

### *4.2 Social network between public and private sector*

The social network in Taiwan's high-tech industry presented itself as a unique structure. In fact, many major semiconductor firms were spins-offs of ITRI/ESRO, which not only transfer technology but also provide human resources for the new companies. Most of the important figures in Taiwan's semiconductor industry, both in the government and the private sector, began their careers in these two organisations. Personal ties, based on common professional background also provided a trust-based relationship for linking firms in the production networks.

#### 4.3 *The high-tech cultivator: the Industrial Technology Research Institute*

The Industrial Technology Research Institute (ITRI) is one of the most important innovative institutional devices that the Taiwanese State has employed to direct the path of industrialisation. In the case of the semiconductor industry, the scale and scope of the industry in Taiwan expanded on its secure foundation of the technological capabilities acquired within ITRI/ERSO, and diffused to a small number of firms. Mathews and Cho (2000) comment on the remarkable success of this institutional device in the process of technology development, where capability rapidly moved from the public sector to the private sector. They stated that the

“Taiwan government’s approach to the upgrading of technological capabilities within industry has been pursued using innovative institutional frameworks over the course of the three decades, 1965 to 1995. These frameworks have co-evolved with the industries they have fostered. The major sources for leverage have been training and engineering development; multinational investments and joint ventures; institutional support in the form of ITRI/ERSO; infrastructure such as the Hsinchu Science-based Industry Park.”

ITRI is the powerhouse behind Taiwan’s entry into semiconductors. It is a source of information, manpower, and other advanced technology for the semiconductor industry. ITRI has successfully built close working relationships with both private and governmental sectors. As a quasi-state-owned R&D institute, it conducts pre-competitive research on projects sponsored by the Ministry of Economic Affairs, with a view to transferring the outcomes to the private sector non-exclusively. ITRI also conducts short and medium-term research projects for the private sector, and is engaged with industry associations in the formation of various R&D collaborative consortia, designed to keep Taiwan firms abreast of world technological best practice. ITRI’s organisational goals in technology leverage and technology innovation and against profit-seeking have fostered partner relationships with both government agents and private firms.<sup>9</sup>

#### 4.4 *The role ITRI plays in implementing environmental policy*

ITRI is not only the engine for developing new industries, it also plays a strategic role in implementing environmental policy in Taiwan’s high-tech industries. There are three important factors, which support this role.

- From ITRI’s perspective, clean technology and environmental management systems are attractive, innovative technologies on the technology horizon which will increase Taiwan’s economic competitiveness in both high-tech and traditional industries. ITRI, therefore, has done research devoted to implementation of ISO 14000, life-cycle analysis, eco-labelling, waste reduction technology and air pollution control technology, and so on, in Taiwan firms.
- Due to its technology capacity and social network relations with industry, ITRI was requested by the Taiwan EPA and IDB to explore greener technologies with firms to delineate the need for regulatory criteria. For example, the most recently announced air pollution emission standards incorporated one of ITRI’s projects to explore high-tech firms’ technological capability in reducing air pollution emissions. Based on its findings, ITRI made suggestions to the Taiwan EPA to set the air pollution emission standards.

- A cooperation and trust relationship has been developed between Taiwanese industries, especially high-tech industries, and ITRI.

Environmental management systems and clean technology promoted by ITRI are likely to be accepted as tools to assist the competitiveness of firms, instead of being rejected as disruptive barriers to firms' profit seeking. As stated earlier, within Taiwan's high-tech industries, over 50% of firms have ISO 14000 certification. There are also on-going waste reduction technologies and life-cycle analysis research projects on the part of ITRI for Taiwanese firms. Clearly, with the help of ITRI, in terms of voluntary environmental technologies and environmental management systems, the rate of implementation is impressive for high-tech industries in HSIP.

## 5 Discussion

### 5.1 *Social sphere: environmentalism and environmental NGOs*

The development of environmentalism in Taiwan has considerably lagged behind the evolutionary thinking of environmentalism in Western societies (Hsiao, 1994). Taiwan's environmental awareness was not awakened until the 1970s, and then was limited to a small group of people, mainly from the intellectual class. Not until the late 1980s, did the general public's concern over environmental issues bloom.<sup>10</sup> In contrast with the West, environmentalism in Taiwan from the 1970s to 1980s remained rather focused on local issues. Hsiao's (1994) study of Taiwan's environmental movements from 1980 to 1991 revealed that, before the mid-1980s, the resources for mobilising environmental movements and the emotional resolve for dealing with environmental problems were intertwined with the attempts of political liberalisation movements.<sup>11</sup> Ecological rationalisation, arguably, has thus followed an independent course, especially in its early stages.

The lift of 'Martial Law' as a key event in Taiwan's democratisation was also a significant benchmark for Taiwan's environmental reforms. After the lift of 'Martial Law' in 1987, Taiwan's environmental NGOs increased the number and scope of issues addressed, from a focus on mainly environmental protection issues to concern with more diverse and complex ecological issues. In the following period, environmental protection movements tended to be more organised and institutionalised. In Hsiao's survey of Taiwanese environmental NGOs (1997), resource sharing, and exchange and support relationships characterised the trend in the relationship between governmental environmental agents and environmental NGOs. However, tactics of competition and not just sharing are also utilised within this symbiotic relationship.<sup>12</sup>

### 5.2 *Political sphere: environmental policy transition*

Examining environmental policy and regulatory frameworks, we may observe that there were increasing environmental legislation and regulations enacted in the past few years. The most significant institutional change was enacted by the Environmental Impact Assessment Act in 1994, in which consultation with academia, NGOs, and non-governmental experts were required in establishing environmental regulations. Such a participatory policy-making process is crucial in EMT. In addition, Taiwanese

environmental policy has so far adopted few measures to economise ecology, such as air pollution and water pollution permits, and garbage-bag charges. Use of economic incentives to achieve environmental protection goals were specifically stipulated in the 1998 National Environmental Protection Plan. Lastly, beyond pollution control, preventive measures are implemented in the Taiwan environmental regulatory regime, as exemplified in the 1994 Environmental Impact Assessment Act.

### *5.3 Economic sphere: industrial policy and industrial structure*

A government must rely on cooperative relations when dealing with industry on environmental issues. However, equally significant is the willingness of the industrial sector to accept the authority of the State, and the fact that government policies do make a difference to the relevant factors. In implementing rigid pollution control measures, governmental agents such as the IDB face a constant struggle to protect the vulnerable small and medium-scale factories since they constitute a vital stream of economic growth for Taiwan.<sup>13</sup>

In a developmental state like Taiwan, the State plays a leading role in making blueprints for the industrial landscape. Details of economic development strategies were stipulated in the Economic Development Plan. Pollution control first appeared on the agenda in the 1986–1989 plan. The Taiwan government began to incorporate environmental considerations into economic development.<sup>14</sup> Under this guideline, several structural transformations are revealed.

- The latest competitive shift in industrial structure has moved from high-pollution industries to lower-pollution industries. The new high-tech industries promoted under the Statute for Upgrading Industry are considered relatively clean.
- There are governmental economic development agents other than the Taiwan EPA, involved in environmental protection efforts, such as the Industrial Development Bureau's 'sustainable industries project,' and ITRI's facilitation of 'eco-labelling,' waste reduction, life-cycle analysis, and 'ISO 14000' implementation.

The rationale of economising ecology is embedded in the Taiwan government's motivation for incorporating environmental consideration into economic development. The increasing demand to manage the environmental crisis in Taiwan also creates immediate pressure for the Taiwan government to make an institutional response. Two considerations are also factored into the plan of promoting 'eco- industries.'<sup>15</sup>

- Meeting the increasing international competitiveness demands for cleaner production.
- Anticipating future growth in the demand for environmental technology in South-East Asia, which has a similar economic infrastructure and has experienced similar environmental degradation.

### *5.4 Embedded autonomy and environmental policy in high-tech industries*

There are increasing environmental concerns regarding Taiwanese high-tech industries. However, it is acknowledged that voluntary environmental management in high-tech

industries, especially in HSIP, is comparatively better than in those traditional industries and those firms which are not situated in the HSIP.<sup>16</sup> The better environmental management systems in high-tech industries can be attributed to their intrinsic nature, which involve continuous technology innovation, making it possible for such companies to adopt the most advanced environmental technologies. Also, as export-oriented industries, intense international competition in high-tech industries makes firms vulnerable if environmental regulations are not met. In the case of Taiwan, the embedded social relationships between government agents, typically ITRI, and high-tech firms directly facilitate the implementation of advanced clean technology and environmental management systems. This social network is not only manifested in the relationship between private and public sectors, but it is also manifested in the informal network organised by environmental and occupational safety professions in HISP firms. Unaffiliated firms share their environmental and occupational safety information informally, which creates an important learning environment for advancement in environmental management.

## **6 Conclusion and future research**

Two main questions are addressed in this study.

- The extent to which environmental reform is taking place in Taiwan, and what mechanisms bring about the reforms.
- An examination of the usefulness of EMT concepts for evaluating and shaping environmental protection efforts in Taiwan.

A few arguments are developed here. The increasing strength of civil society is salient in Taiwan. Taiwan's environmentalism is on the rise. With the development of democratisation, the civil society sector has begun to gain a foothold to bargain with the government on environmental policy-making, although the number of successful cases remains small. In terms of the advancement of environmental policy, environmental management techniques, the improvement in the measures of air and water quality, and the restructuring of industry, Taiwan shows promising signs of moving toward the path of ecological modernisation. The ecological modernisation process has taken place in Taiwan via the unique political economic structure of the embedded relationship between the State and business. Taiwan as a developmental state strategically uses its embedded social networks in promoting environmental management and technology as manifested in the role that ITRI plays in environmental policy in high-tech industries. High-tech firms have increasingly adopted environmental practices consistent with ecological modernisation hypotheses, such as ISO 14000, life-cycle analyses, the abandonment of CFCs, and other environmental management techniques. In short, in Taiwan, it appears that embedded social network relationships between the State and firms assist firms to take an ecological modernisation path.

As for the Taiwan government's motives, findings in this paper are consistent with what Rock (1996) has found in his research. The factors contributing to the Taiwan government's continuous efforts in environmental protection include the process of democratisation, growing public awareness about environmental issues, international

competitiveness, gaining first-mover advantage, and export opportunities for green technology to the less developed countries, as well as cost considerations.

To some degree we may find that ecological modernisation does cast some light on the dynamics of environmental reforms in Taiwan. However the result of dematerialisation efforts is too early to judge. Although Taiwan's environmentalism is rather underdeveloped in comparison with the West, the prevalence of 'sustainable development' discourse, and the adoption of environmental management and other technical and policy innovations seem to suggest that it is catching up with its counterparts in the West. Many environmental measures have been implemented, and environmental information is gathered and presented by the Taiwanese government. However, to what degree this is a consequence of symbolic functions rather than rational ecological choices remains unknown. Direct evidence of dematerialisation and the results of environmental reform will not be realised for some years. Therefore, it would be fair to conclude that Taiwan's environmental reform, as the measure of 'process,' does move toward ecological modernisation. Nevertheless in terms of the measure of dematerialisation, this is not so conclusive.

As stated earlier, some authors have questioned EMT's applicability for explaining environmental reforms in less industrialised countries and newly industrialising countries. Several researchers have begun to address the question. Mol and colleagues developed a research agenda intended to broaden EMT geographically (Mol and Sonnenfeld, 2000). Frijin et al. (2000) studied the ways in which globalisation processes might catalyse ecological modernisation processes in less industrialised countries. David Sonnenfeld (Sonnenfeld, 2000; Mol and Sonnenfeld, 2000) studied the applicability of EMT in newly industrialised countries (NICs), specifically focusing on the efforts of efficiency improvement, waste reduction, and cleaner production processes in pulp and paper industries among South-East Asian countries in the late 1980s and early 1990s. He found that the greening efforts in pulp and paper industries in South-East Asian countries partially fulfills EMT's hypothesis. However, there was no evidence of dematerialisation in the cases he studied. Observing the uneven distribution of green practices, Sonnenfeld's research concluded that the dynamics of ecological modernisation exist in large-scale, export-oriented modern sectors of NIC economies, but are less prevalent in small and medium-size enterprises (SMEs).

Another study of the applicability of EMT in NICs is by Frijin et al. (2000). Analysing environmental restructuring of contemporary economic developments in Viet Nam, Frijin and his colleagues found that Viet Nam's environmental reform path deviated from the environmental reform trajectory hypothesised by EMT. Viet Nam's environmental policy system is incapable of execution, and has been unable to develop and implement environmental technologies. Independent environmental NGOs are scarce and environmental activities among economic agents are absent. Also, environmental awareness among the public is too weak to trigger social movements that could put sufficient pressure on governmental and industrial organisation for radical ecological reform.

Comparative studies in EMT across different developmental levels of countries test the global applicability of EMT. However, applying EMT in NICs thus far has returned no conclusive argument. The case of Viet Nam challenges the force of globalisation in modernising ecological rationality in a less developed country. It implies that time and developmental stage matters, and the mechanisms of globalisation of ecological modernisation are hardly taking effect. That is, until economic development and/or



political democracy have reached a certain level, ecological consideration in social and economic development has no visible position. In contrast, Sonnenfeld's study (2000) showed that globalisation is effective in shaping environmental reform in NICs. Ecological modernisation is happening in large-scale, export-oriented modern sectors of NIC economies. The study of Taiwanese environmental reform discussed in this paper agrees with Sonnenfeld's conclusion that large-scale, export-oriented modern sectors like high-tech industries do show more evidence in taking an ecological modernisation course. However, in the case of Taiwanese high-tech industry, the leading role that the State plays in promoting environmentally sound technology and management, and the embedded autonomous State–Society structure are compounded with the globalisation force to lead high-tech industries to pursue ecological modernisation.

Mol stated that, in the globalising world, with modern industrialised countries still providing the dominant models of economic development, models of ecological reform that are believed to be inappropriate for non-OECD countries might still be imposed upon these countries through a diversity of mechanisms.<sup>17</sup> Without real informed environmental knowledge and consciousness, the implementation of environmental regulation is not going to promise Taiwan a sustainable future.

In this paper, social dynamics, environmental policy and industrial policy are carefully reviewed. Further data or information gathering on the business sector's rationalisation of environmental reform is essential in answering the above questions.

In the light of EMT, Taiwan's case brings out a challenge for future discussion. As discussed in the political economy literature, as Taiwan is an NIC, a developmental state, its economy is not completely independent from the State. Can we expect a future of 'ecological emancipation from the economic sphere'? In other words, how an ecological modernisation process is going to proceed in a society where the functions of the political and economic spheres are much compounded remains to be explored.

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## Notes

<sup>1</sup>This paper is based on a paper initially prepared for a presentation at the NRRG-ETS Environmental Policy Symposium: The Political Economy of the Environment. The Symposium was sponsored jointly by the Natural Resources Research Group of the Rural Sociological Society and by the Section on Environment and Technology of the American Sociology Association. It was held in Washington DC, on August 15, 2000.

<sup>2</sup>The Taiwan Greenpeace Association is an independent entity, which has no association with Greenpeace.

<sup>3</sup>Units for Taiwan EPA data are metric tons.

<sup>4</sup>Population growth, industrial development, and economic activity themselves increase air pollutant emissions. The increment of increasing air pollution emission due to such growth, so-called 'air pollutant natural growth emission,' is unavoidable in social development processes. Pollution controls are mitigating this growth-related momentum in emissions.

<sup>5</sup>The main air pollutant emission sources in Taiwan are stationary sources (factories and construction sites) and mobile sources.

<sup>6</sup>By comparing the percentage with those in 1986 and 1987, the rates of progress were 15% and 68%, respectively.

<sup>7</sup>The 1998 figure was the lowest in 15 years.

<sup>8</sup>In the 1970s, Taiwan's entry into the semiconductor industry was considered late, especially for a state lacking in key areas of technological capacity. Beginning in the 1970s, Taiwan made successful inroads into the semiconductor industry by directly importing key technologies developed by the USA and Japan. The Taiwan government launched its first semiconductor project in 1974. In September 1982, the information industry was selected as a strategic sector in the state's developmental plans, and has since received a string of investments from the government.

<sup>9</sup>The mission of ITRI is technology transfer. It is arguably the most capable institution of its kind in the world in scanning the global technological horizon for developments of interest to Taiwan industry and executing the steps required to import the technology. Projects undertaken by ITRI were designed both to facilitate the creation of new industries, as in the case of semiconductors (but also fine chemicals, pharmaceuticals, optoelectronics, aerospace), and to upgrade existing industries. The semiconductor industry has certainly been ITRI's greatest industry creation success story.

<sup>10</sup>According to Hsiao's surveys in 1983 and 1986. In 1983, 70% of the public rated pollution as serious or very serious; by 1986, the figure had jumped to 88%. In 1983, 51% of the public thought pollution would get worse over the coming five years; by 1986, this had risen to 70%.

<sup>11</sup>The benchmark of the environmental movement is the removal of 'martial law' on July 15, 1987.

<sup>12</sup>An interview with a veteran environmental activist indicated that there is a transformation underway in the strategies of Taiwanese environmental movements from oppositional to participatory, from hostile to cooperative. It is also evident in an environmental protection movement in HSIP, where the slogan 'Against Pollution, Not Against Business' is used.

<sup>13</sup>Information gained from interview with IDB staff.

<sup>14</sup>Three methods are implemented for this purpose. First, an import-substitution industrial development strategy is being followed to create an indigenous environmental goods and services industry. Second, industry purchases of pollution control and abatement equipment are heavily subsidised. Third, the government is financing research into pollution prevention and providing industry with subsidised technical assistance in waste reduction/minimisation.

<sup>15</sup>Information gained from interviews of IDB and ITRI staffs.

<sup>16</sup>HSIP was created by the government to provide an infrastructure to facilitate and accelerate the process of technological diffusion, and to localise the vertical division of labor among semiconductor firms.

<sup>17</sup>E.g., the political mechanisms such as the international development programs of various nation-states and international actors (such as the World Bank and the IMF) or the emphasis put on the transfer of environmental technology from industrialised countries to developing countries in the UNCED declaration, the Montreal Protocol, and the elaboration on the Framework Convention on Climate Change.

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