



Environmental Impacts of Trade Liberalization and Policies for the Sustainable Management of Natural Resources

A Case Study on Chile's Mining Sector



Environmental Impacts of Trade Liberalization and Policies for the Sustainable Management of Natural Resources

A Case Study on Chile's Mining Sector

National Institution leading the Study:

Centro de Investigación y Planificación del Medio Ambiente (CIPMA)
Santiago, Chile

National Team Contributing Authors:

Nicola Borregaard, Giulio Volpi, Hernán Blanco, Françoise Wautiez
and Andrea Matte-Baker



UNITED NATIONS
New York and Geneva, 1999

NOTE

The views and interpretation reflected in this document are those of the author(s) and do not necessarily reflect an expression of opinion on the part on the United Nations Environment Programme.

UNEP/99/1

The United Nations Environment Programme

The United Nations Environment Programme (UNEP) is the overall coordinating environmental organisation of the United Nations system. Its mission is to provide leadership and encourage partnerships in caring for the environment by inspiring, informing and enabling nations and people to improve their quality of life without compromising that of future generations. In accordance with its mandate, UNEP works to observe, monitor and assess the state of the global environment, and improve our scientific understanding of how environmental change occurs, and in turn, how such changes can be managed by action-oriented national policies and international agreements.

With today's rapid pace of unprecedented environmental changes, UNEP works to build tools that help policy-makers better understand and respond to emerging environmental challenges. Towards this end, UNEP provides policy-makers with useful tools to monitor the environment, such as integrated environmental and sustainability indicators, and models for effective tools to manage it, such as economic instruments. UNEP's work concentrates on helping countries strengthen environmental management in diverse areas including freshwater and land resource management, the conservation and sustainable use of biodiversity, marine and coastal ecosystem management, and cleaner industrial production and eco-efficiency, among many others.

UNEP, which is headquartered in Nairobi, marked its first 25 years of service in 1997. During this time, in partnership with a global array of collaborating organisations, UNEP has achieved major advances in the development of international environmental policy and law, environmental monitoring and assessment, and our understanding of the science of global change. This work has, and continues to support, successful development and implementation of the world's major environmental conventions. In parallel, UNEP administers several multilateral environmental agreements including the Vienna Convention's Montreal Protocol on Substances that Deplete the Ozone Layer, the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), the Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal (SBC), the Convention on Biological Diversity and most recently, the Convention on Prior Informed Consent Procedure for Certain Hazardous Chemicals and Pesticides in International Trade (Rotterdam Convention, PIC). In recent years, UNEP has also been an important catalyst, and major supporter, of continuing international negotiations on an international agreement to deal with the problem of persistent organic pollutants (POPs).

The Division of Technology, Industry and Economics

The mission of the Division of Technology, Industry and Economics (DTIE) is to encourage decision-makers in government, industry, and business to develop and adopt policies, strategies and practices that are cleaner and safer, use natural resources more efficiently and reduce pollution risks to both human beings and the environment. The approach of DTIE is to raise awareness by fostering international consensus on policies, codes of practice, and economic instruments through capacity-building and information exchange and by means of demonstration projects.

The Economics and Trade Unit

The Economics and Trade Unit (ETU) is one of the units of the Division of Technology, Industry and Economics (DTIE). The work programme of the Unit consists of three main components, economics, trade and financial services. Its mission is to enhance the capacities of countries,

particularly developing countries and countries with economies in transition, to integrate environmental considerations in development planning and macroeconomic policies, including trade policies. UNEP's mission in this field is also to address the linkages between environment and financial performance and the potential role of the financial services sector in promoting sustainable development. The trade component of the Programme focuses on improving countries' understanding of the linkages between trade and environment and enhancing their capacities in developing mutually supportive trade and environment policies, and providing technical input to the trade and environment debate through a transparent and a broad-based consultative process.

For information on UNEP's Programme on Economics and Trade, please contact:

Hussein Abaza
Chief, Economics and Trade Unit (ETU)
Division of Technology, Industry and Economics (DTIE)
United Nations Environment Programme (UNEP)
15, chemin des Anémones
CH-1219 Chatelaine/Geneva

Tels: (41-22) 917 82 98, 917 81 79;

Fax: (41-22) 917 80 76;

E-mail: hussein.abaza@unep.ch

PREFACE

With the recent acceleration of global trade, countries throughout the world have benefited from more investment, industrial development, employment and income growth. Recognising that the benefits of trade can strongly contribute to the improvement of basic living standards, many of the world's developing countries and countries with economies in transition, have sought to actively participate in the global trading regime. For most of these countries, efficient and effective participation in the global economy has required substantial economic restructuring at home. Thus, in recent years, national governments have implemented structural adjustment programmes to stabilise and reorient their economies in order to face the challenges of development. This included in the first instance the restructuring of economies to increase foreign exchange earnings through enhanced trade and trade liberalisation as embodied in the set of agreements of the World Trade Organisation (WTO).

National experiences with structural adjustment programmes have been mixed. Nevertheless, trade liberalisation elements of restructuring programmes have facilitated the rapid growth of targeted export markets, and succeeded in attracting much needed foreign investment to fuel continued economic growth. Recently, however, many undesirable effects of rapid increases in trade have emerged. Affected countries find that inadequately managed economic activities, supporting, or supported by, growing trade, often result in serious environmental degradation. Air, water and soil pollution, and unrestrained natural resource exploitation, grow to levels that jeopardise the viability of the economic activities they support. Trade thereby becomes unsustainable.

The United Nations Environment Programme (UNEP) believes that the potential for negative impacts of trade on the environment can be minimised, if not avoided entirely, by integrating environmental considerations—that complement rather than inhibit trade—into development planning. Over the past two years, UNEP has worked closely with six countries—Bangladesh, Chile, India, Philippines, Romania and Uganda—on comprehensive projects to identify the impacts of trade liberalisation on national environmental resources and the use of economic instruments to sustainably manage these impacts.

These projects have encompassed new action-oriented research on unique trade-related environmental problems and their social and economic implications in diverse sectors and varied country settings. Importantly, projects have involved multi-stakeholder participation in numerous consultations to accurately identify the dynamics of environmental degradation, and to develop innovative and widely acceptable national response strategies. Each study concludes by recommending a set of practical measures—comprising ready-to-apply command and control measures and economic instruments designed to meet national conditions—that promise to effectively halt trade-related environmental degradation, and in turn, ensure that the country's trade remains robust yet sustainable over the long-term. But the projects do not end with published studies, the final component of each country project involves a pilot implementation of proposed measures undertaken by national authorities in collaboration with each project's national team and UNEP.

This report on the Chilean mining sector, is one in a series of UNEP publications presenting country studies implemented under a first phase of "Capacity Building for Integrating Environmental Considerations into Development Planning and Decision-making" projects funded by the European Commission. Other projects in the first round examine the shrimp farming industry in Bangladesh, the automotive industry in India, the Romanian water sector, the Philippines' forestry sector, and the Ugandan fisheries sector.

As we approach the WTO's Third Ministerial Meeting in Seattle, which may mark the launch of the next round of trade negotiations, this report provides a valuable source of information and knowledge on Chile's experience with the environmental impacts of trade liberalisation and the development of measures to address these impacts and promote sustainable trade and environmental policies.

The complex trade-environment dynamics and innovative strategies to manage emerging environmental problems of the Chilean mining sector are presented and discussed in detail in this report. The insights that this, and other reports in the series provide, make the series an extremely valuable resource for policy-makers and sectoral practitioners aiming to effectively address the emerging environmental impacts of trade in their own countries.

ACKNOWLEDGEMENTS

The preparation of this country report on the Chilean Mining sector has been made possible by the cooperation and commitment of many individuals and organisations.

The Chilean national team - the author of this report - is to be commended for taking the lead in project execution. Led by Nicola Borregaard of the Centro de Investigación y Planificación del Medio Ambiente (CIPMA), the team gathered field data, designed and implemented interviews and a survey directed at different national actors, analyzed economic and environmental trends, developed policy recommendations, and reported on their activities and research results.

All of the national actors involved are to be thanked for the valuable contributions they made to the project's objectives and success.

The Economics and Trade Unit (ETU), Division of Technology, Industry and Economics (DTIE) of the United Nations Environment Programme (UNEP), was responsible for the overall coordination and management of all six country projects. Through a joint UNEP-UNCTAD (United Nations Conference on Trade and Development) collaboration, René Vossenaar and Veena Jha provided technical guidance and assistance to the national teams on various aspects of their research. International expert meetings further provided a forum for project implementation review by national teams and representatives of relevant international and United Nations organisations.

Once the national team had completed their final report, Eugenia Nuñez, Desiree Leon and Rahila Mughal of UNEP worked closely with an external editor, Andrea Matte-Baker, to process the report for publication.

Finally, it must be recognised that like so many international environmental research projects, funding from interested sponsor governments is the key to their existence. UNEP is indebted to the European Commission who generously provided the financing that made this project possible.

TABLE OF CONTENTS

	<i>Page</i>
INTRODUCTION.....	1
1. EXPLORING THE RELATIONSHIP BETWEEN TRADE AND ENVIRONMENT: THEORETICAL AND METHODOLOGICAL CONSIDERATIONS.....	5
1.1 The Theoretical Underpinnings.....	5
1.2 Range and Nature of the Potential Effects of Trade on the Environment.....	5
1.3 The Analytical Tools.....	7
1.4 Assessment in Action.....	9
1.5 Towards an Assessment Framework.....	10
2. THE MINING SECTOR IN CHILE: GENERAL CONTEXT.....	15
2.1 Structure and Role of the Mining Sector.....	15
2.2 Internal Influences in the Process of Trade Liberalization: The Evolving Policy Framework.....	18
2.3 External Influences in the Process of Trade Liberalization: Changing World Markets.....	21
3. ECONOMIC EFFECTS OF TRADE LIBERALIZATION IN THE MINING SECTOR IN CHILE.....	25
3.1 Economic Evolution and Trends.....	25
3.2 Economic Effects of Trade Liberalization.....	26
4. ENVIRONMENTAL IMPACTS OF TRADE LIBERALIZATION IN THE MINING SECTOR IN CHILE.....	31
4.1 The Environmental Regulatory Framework.....	31
4.2 Environmental Impacts of Mining.....	35
4.3 The Mining Sector and Environmental Problems in Chile.....	38
4.4 Environmental Effects of Trade Liberalization.....	40
5. LEARNING FROM EXPERIENCE.....	45
5.1 The Assessment Process.....	45
5.2 Lessons from the Mining Sector in Chile.....	47
5.3 Looking to the Future: Towards an Improved Policy Framework.....	49
ANNEXES	
I. Assessment of the Effects of Trade on the Environment: Current Analytical Tools.....	53
II. Environmental Impact of Trade Liberalization: Review of the Empirical Evidence.....	56
III. Institutional Arrangements for Environmental Assessment of Trade.....	59
IV. Agreements on Environmental Cooperation Between Chile and Canada.....	61
V. Major Foreign Investment Projects in the Mining Sector in Chile.....	62
VI. Environmental Policy and Emission Reduction Plans in the Mining Sector.....	67
VII. Environmental Policy and Management at Escondida Mine.....	69
REFERENCES.....	71
LIST OF CONTRIBUTORS.....	79

INTRODUCTION

The Context of the Debate

As interactions between countries increase and the world faces globalization of the economy, there is widespread concern about the effects the ongoing process of trade liberalization will have on sustainable development and, in particular, on the environment. After years of perceived contradictions between free trade and environmental protection, a common perspective was agreed upon at the 1992 United Nations Conference on Environment and Development (UNCED). There Governments endorsed the call to address the issue and “make international trade and environmental policy mutually supportive”. However, at the time, little was said on how to operationalize this goal. The task of making international trade work for environmental sustainability, instead of against it and of devising ways in which to achieve an effective integration of trade and environment policy is a challenge that is still before us.

In the post-UNCED period, environmental review and assessment has been identified as a key mechanism for achieving integration between trade and environmental policies. The 1995, 1996 and 1997 sessions of the Commission on Sustainable Development (CSD) stressed the importance of developing a framework to facilitate assessment of the environmental impact of trade policies and called upon UNEP, UNCTAD and UNDP to cooperate in this endeavour. However, the World Trade Organization (WTO)—the prime international forum for discussions on trade—has not yet moved in this direction; its Committee on Trade and Environment has not taken up on proposals recommending that Governments undertake reviews of trade agreements and share the results with other member States. In a bid to progress more rapidly, during the 1997 review of the implementation of Agenda 21, Governments stressed once more that “decisions on further liberalization should take into account effects on sustainable development” (UNGASS, 1997).

Various international and national bodies have undertaken specific initiatives to address the interaction between trade and environment. The development of basic principles and environmental guidelines for achieving policy integration has already started (OECD 1993, UNEP 1995), but as yet, few countries have undertaken national studies or systematically addressed the issue. The European Community (EC) has promoted action because of the constitutional requirement of the Maastricht Treaty that environmental protection be integrated into the definition and implementation of Community policies. Its 1996 ‘Communication on Trade and Environment’ to the Council and Parliament, emphasized the urgent need to undertake reviews of trade instruments and agreements with a view to identifying potential environmental impacts and devising appropriate policy responses.

In practical terms, however, coordination and action to enhance policy integration has been fairly limited. Among the reasons for the slowness of progress is the inherent difficulty encountered in examining the problems and opportunities that arise as an exclusive result of trade. In effect, it is often impossible to isolate the effects caused directly by trade from those resulting from economic activity in general; determining the environmental effects is doubly difficult because of the nature of environmental problems. Likewise, because of these uncertainties, it has been difficult to devise appropriate policy responses. The question is then, how to assess the environmental effects of trade liberalization and at the same time, devise appropriate policies to correct negative impacts. But beyond that, the question is how Governments can contribute to integrating concerns

for the environment in policies related to economic development and trade and correct failures by the market to assign adequate values to environmental resources.

The UNEP Study

As a contribution to ongoing efforts to address these questions, the United Nations Environment Programme (UNEP), with the support of the European Union, has undertaken to explore various issues connected to trade liberalization and the environment.

Of particular concern to UNEP is the clarification of some of the methodological questions connected to the assessment process itself, the exploration of the mechanisms whereby trade has an effect on the environment, and finally, determining, if and how, trade can contribute to better resource allocation, technological innovation and eventually, environmental protection.

The work was conducted by a team of specialists on behalf of UNEP. Initial research work was done within the UNEP Secretariat; the case study work was done by local experts in Chile. These efforts resulted in two extensive reports which are hereby presented in synthesized form.

The approach used by UNEP included organizing the study around several themes, namely:

- a preliminary review of work done to date in assessing the effects of trade on the environment, both from the methodological and empirical point of view; this involved examining the most recent literature as well as conducting interviews with those concerned with trade-environment links in countries where some degree of policy integration is being pursued;
- the outlining of a generic and flexible framework for assessing the environmental effects of trade liberalization; this was done on the basis of the research findings, adapting basic assessment techniques to the dynamics of trade-environment relationships; this was subsequently applied to the case study review in Chile, as a means of testing its wider applicability;
- the exploration of a concrete situation; in this particular instance, a case study on the effects of trade liberalization in the mining sector in Chile. The mining sector in Chile was chosen as an illustrative example, first, because Chile has gone through a process of ever increasing trade liberalization over the last two decades, secondly, because the mining sector is one of the most influential productive sectors of the country's economy and accounts for a significant portion of its trade volume, and thirdly, because mining has significant and visible environmental impacts. Research was done through literature reviews and interviews.

Rationale and Organization of the Report

The present report is organized in the following manner:

- review of the most important factors influencing both thinking and the assessment of the impacts of trade on the environment, including proposals for an assessment framework. This section is intended as a summing up of current experience and as a means of setting the stage for future work.
- review of the overall economic and regulatory context in which the mining sector in Chile operates. This is intended as a backdrop to the study itself.
- review of the economic and environmental impacts resulting from trade liberalization in the mining sector in Chile. These two sections are intended both as an exploration of the effects of trade on the environment in a specific case, as well as a demonstration of how the proposed assessment framework can be applied.

- assessment of the implications of the findings from the methodological and policy perspectives followed by corresponding recommendations for action.
- annexes include material providing greater detail on the various points that are treated more synthetically in the body of the report, followed by a list of references used in the original studies. This is intended as a source of additional information.

It is hoped that the results of this work will contribute to further current understanding of the overall issues and reality of trade liberalization, as well as assist in the ongoing development of accessible tools for assessment of environmental impacts and policy integration. In time, progress in this field will hopefully lead to a more environmentally sound and sustainable pattern of trade and global economic integration.

1. EXPLORING THE RELATIONSHIP BETWEEN TRADE AND ENVIRONMENT: THEORETICAL AND METHODOLOGICAL CONSIDERATIONS

1.1 The Theoretical Underpinnings

Exploring the relationship between trade and environment and, in particular, assessing the effects of trade on environmental quality is a complex and far-from-straightforward task. This is due in part to difficulties in isolating trade-related environmental effects from the effects of economic policies and economic activity in general. Free trade regimes are often associated with general economic policy reforms, making it all the more difficult to separate the effects of one from the other. It is because of this that, to date, there has been no systematic attempt to make a specific case of trade issues: the general assumptions and tools of economics and of environmental assessment have been applied to the analysis of trade and environment interactions without significant modifications.

Standard environmental economics posits that environmental degradation is primarily due to inadequate natural resource management, itself the result of policy and market failure at the national level (Pearce 1993, Barde 1994). Markets fail to properly value environmental assets, creating distortions in the market's allocation of resources; when prices of goods and services do not reflect their full environmental costs, excessive exploitation of unpriced factors occurs and ultimately results in resource degradation; when governments do not succeed in correcting market failure or further exacerbate them through their policies environmental degradation persists.

It is argued that, to the extent that trade liberalization is directed to correcting policy-related market distortions—such as export subsidies—it should have positive effects on the environment. But full internalization of environmental costs is rarely possible and sound environmental policies have not yet been universally implemented. In these circumstances, trade liberalization will contribute to magnify existing environmental problems.

1.2 Range and Nature of the Potential Effects of Trade on the Environment

In an attempt to provide a more specific analytical framework to examine the relationship between trade and environment, five major categories of potential effects have been described in the literature (Grossman and Krueger, 1991, OECD 1994, UNEP 1995). The actual effects of trade will naturally depend on the context in which trade liberalization occurs and the degree to which policies and structures address potential negative effects.

1.2.1 *Quantity or scale effects*

It is widely accepted that trade liberalization has significant macro-economic effects, particularly on the level of economic activity, and influences the utilization of natural resources, energy and materials as well as pollution levels. Most authors agree that growth in economic activity is largely beneficial, although others have criticized the standard economic analysis involved in assessing gains of free trade (Daly, 1993).

Positive scale effects may occur when economic growth creates an increased demand for improvements in environmental quality and financial gains are used by both public authorities and private companies to address environmental problems. It does not, however, necessarily follow that economic gains will be automatically used for environmental protection, or, indeed, that any improvements in environmental quality will ensue.

Negative scale effects may occur in the absence of sound environmental management and internalization of environmental costs: growth increases both the use of natural resources and the 'throughput' of materials and energy and associated pollution. This is particularly the case with common goods or resources when there is no incentive to restrain individual behaviour (Hardin, 1968); producers using these resources will also increase profits by not spending on environmental protection measures (Esty, 1995). In this situation, trade-induced economic growth leads to higher pollution and unsustainable patterns of production and consumption (OECD, 1994).

1.2.2 Structural or sectoral effects

Effects associated with the patterns of economic activity and the processes of resource use and production are an indirect result of trade liberalization. Classical trade theory posits that free trade enables countries to specialize in the export of goods that incorporate proportionately more of those factors of production that they possess in relative abundance and best reflect their natural endowment. This leads to a competitive advantage over other countries and lower prices; it also means that global material welfare can be attained at a lower factor input, including environmental resources, than would be the case if countries attempted to satisfy all requirements through local production alone (Johnstone, 1996).

Positive structural effects may therefore occur when free trade allows productive specialization that in turn leads to more efficient and appropriate allocation of resources and economic activity within and between countries, in accordance with environmental capacities.

Negative structural effects may occur when there are no appropriate mechanisms to evaluate and internalize environmental costs. This in turn leads to mis-allocation of productive resources and/or over-exploitation of natural resources and specialization in pollution-intensive goods and industries (Arden-Clarke, 1991).

1.2.3 Technology effects

The removal of border constraints, improved intellectual property regimes and other trade liberalizing policies can have an influence on the way environmentally sound techniques and technology are distributed internationally. An important consideration in this context is the extent to which international investments and multinational companies are active in establishing environmentally sound operations, particularly in developing countries where regulations may not be stringent. For many of these countries, access to improved technology and management systems can represent a significant environmental benefit (Esty 1995). Some analysts also suggest that setting up cleaner production may be a function of economies of scale, with larger companies better positioned than smaller scale or cottage industries (Repetto, 1994; Markandya, 1995).

Positive technology effects may occur when opening-up of markets results in expanded sales opportunities and easier dissemination of environmentally friendly goods, services and technologies. New and cleaner technology can reduce both pollution per unit of output as well as overall levels of pollution, thus enhancing both economic and environmental efficiency.

Negative technology effects may occur when environmentally unsound technologies, that are both cheap and/or unsophisticated or obsolete, are promoted by freer trade, or, when pollution-

intensive industry migrates to areas where environmental standards are lower—the so-called pollution havens hypothesis (Esty, 1995).

1.2.4 Product-related effects

Trade liberalization may also affect the composition and type of the products that are exported, which may be either more or less damaging to the environment. The actual composition will of course depend on many other factors outside of the realm of liberalization itself; what freer trade does is influence the access of such products to global markets.

Positive product-related effects may result if trade expansion facilitates access to and exchange of more environmentally sound products, such as less energy intensive and low emission machinery or processes.

Negative product-related effects may result when freer trade merely expands exchanges in environmentally harmful or sensitive products, such as toxic wastes and hazardous chemicals or endangered species or other similar commodities. Because of differing regulations in different countries, freer trade may reduce the incentive to establish stringent national environmental standards; this occurs when toxic wastes are accepted for disposal in countries with lower environmental standards (Johnstone, 1996).

1.2.5 Regulatory and policy effects

The effects caused by the framework for environmental management constitutes a special category, as it depends more on political than economic factors. Changes in trade policies can influence existing environmental policies and standards, both at the national and international levels. Of particular concern are the contradictions that may arise between national and international environmental product standards when they are set at different levels of stringency thus affecting internalization of environmental costs (Arden-Clarke 1991, Charnovits, 1992). This legal dimension has been discussed extensively in the literature concerning GATT provisions, particularly with regard to the WTO Agreement on Technical Barriers to Trade (Ewing, 1997). Following the recent WTO ruling against the EU's ban on hormone-treated beef, it appears as if WTO rules restrict the right of governments to decide what level of environmental or health protection they consider appropriate for their citizens (EC, 1997).

Positive regulatory and policy effects may occur when increased international cooperation resulting from trade agreements and economic integration can help induce institutional changes necessary to develop improved environmental protection and enforcement measures (Rosenberg, 1997). A case in point is the recent agreement on environmental cooperation between Canada and Chile, which could enhance domestic environmental protection.

Negative regulatory and policy effects fall into two categories. First, as domestic economies open up to international markets, countries may not adopt instruments to internalize environmental costs because of concerns that this may affect competitive advantages. Secondly, provisions for international harmonization in trade agreements may not allow national governments to determine the levels of environmental risk which they consider appropriate.

1.3 The Analytical Tools

A variety of analytical tools, methods and approaches to assess the effects of trade on the environment exists. As is apparent from a brief review of those currently being employed (Annex I) most are not rigorously structured nor do they rely on formal methodologies, but are pre-

ponderantly ad hoc tools devised and used on a case-by-case basis. The advantages and disadvantages of the various examples are briefly flagged here.

1.3.1 Environmental impact assessment methods

The manner in which classical environmental assessment techniques have been applied to trade and environment is too varied to be assessed here in specific terms; suffice it to say that any benefits or drawbacks encountered are inherent in the general techniques used and are not necessarily linked to their application to trade-specific analysis. Approaches that combine the use of various techniques are more promising as they seem better able to overcome the uncertainties inherent in appraisal of trade policies and allow a more comprehensive assessment of environmental effects.

1.3.2 Macro-modelling approaches for identifying environmental impacts

Models have shown themselves to be a useful tool for explaining complex economic changes, such as those that occur as a result of trade liberalization. However, because of the arbitrary nature of the assumptions, caution should be exercised in interpreting the findings and policy implications that derive from them. An expert meeting convened by UNEP recognized that the application of models to policy formulation is limited (UNEP, 1995).

1.3.3 Issue-specific focus

The approach that focuses on the effects of growth resulting from trade liberalization using the environmental Kuznets curve (EKC) is interesting because of its overall theoretical consistency. There are however, significant limitations in the type of analysis, particularly because the economic mechanisms by which increases in wealth result in increased environmental protection are poorly understood (de Mestral, 1996), and valid doubts arise when the argument is exaggerated.

Another approach which focuses on specialization in pollution-intensive industries, is interesting because it allows concentration on primarily environmental issues; however, it has been criticized by various authors because of the underlying assumptions of direct or linear relationships between variables, and the manner in which incomplete data are utilized.

1.3.4 Focus on national level effects

The techniques used in these studies are too varied methodologically for it to be possible to derive lessons. However, regardless of the methods used, it has been shown that results of these studies on the whole shed little light on the trade-environment relationship and provide conflicting evidence (Markandya, 1994).

1.3.5 Methods used to review trade agreements

The quality and accuracy of the reviews of trade agreements varies greatly, both because of methodological differences, and more importantly, because they often are done with a view to meeting minimum requirements and in response to public opinion rather than as a means of identifying priorities and integrating the findings in decision-making.

1.4 Assessment in Action

The application of analytical methods to actual case studies has led to the compilation of a considerable body of empirical information, which allows to gauge both the usefulness of the analytical tools as well as draw conclusions on the effects of trade on the environment. Similarly, reviews of existing institutional arrangements for environmental assessment of trade reveal the degree of importance accorded to it.

1.4.1 *Issues of concern in the assessment process*

Considering the performance of analytical tools in practice, it seems apparent that there are some problems. Although the differences in the methodologies employed make evaluation difficult, it is possible to draw some general conclusions. Some of the difficulties are the direct result of the nature of the analytical tools themselves; others are of a more general nature:

- *Problems connected to the underlying assumptions and focus:* General economic assumptions are undeniably coloured by a particular world view, and as such, are not to be questioned on purely analytical grounds; however, it is undeniable that assumption do indeed affect both the analysis and conclusions; these should therefore be approached with an open mind;
- *Omission of important elements:* There appears to be a very strong emphasis on pollution resulting from economic activity; invariably, other environmental problems, including those that are either a direct or an indirect consequence of trade are often ignored; e.g. cumulative and synergistic effects are not often included in the analysis; the range of effects at national, regional and global levels is also not considered systematically;
- *Practical difficulties associated with the analytical process* hinge to a considerable degree either on the lack of data—both economic and environmental—or on the difficulty to manipulate the data that is available; this inevitably distorts the reliability of the analysis;
- *Application of the results of the analysis* appears to be fairly weak; not only are priorities not established, but overall, the results of the analysis often do not seem to systematically inform decision-making at a broader level.

1.4.2 *Drawing conclusions from the empirical evidence*

It is also possible to draw general conclusions on the actual effects of trade on the environment, drawing on the results of the case studies (Annex II). The general thrust of the findings are grouped here according to the categories discussed earlier:

- *Scale effects:* Growth and greater economic activity resulting from trade always show an increase of pressure on the environment, particularly in those cases where use of natural resources—even when correctly priced—increases; this is the case in the energy sector as well as in the case of natural resource-based commodities;
- *Structural effects:* These are shown to have a positive effect on the environment as they appear to offset scale effects by increasing allocational efficiency; changes at the structural/sectoral level show a clear negative impact on the environment in those cases where there is an expansion in pollution-intensive exports—as in the case of various developing countries and countries in transition;
- *Technology effects:* The studies show that improved technologies can, to a certain degree, offset increases in pollution due to expansion of trade-related economic activity; there is little evidence of industry migrating to areas of less stringent environmental standards; trade policies alone do not appear to have an influence on technology transfer, which is shown to take place

only if supportive institutional measures are in place, either at the government level or at the corporate level;

- *Product-related effects*: Few of the studies reviewed revealed positive product-related effects; negative ones were more frequent, as in the case in some countries in transition;
- *Policy and regulatory effects*: There appears to be little evidence of upward harmonization taking place in the policy framework connected to trade, but in some cases it is shown that environmental side-agreements connected to trade, and greater cooperation between States can contribute to building the necessary institutional capacity.

1.4.3 Institutional arrangements

Although all of the examples of existing institutional arrangements reviewed (Annex III) are in developed countries, the review nevertheless gives general indications of the range that exists; it is probable that in many countries in transition and in developing countries roughly similar arrangements also exist. The procedures vary considerably, but those most commonly found include mandatory provisions for environmental review of various policies which also apply to trade; there are also formal and systematic environmental reviews and limited forms of environmental appraisal applied to policy-making. From the institutional point of view, there appears to be considerable reliance on interdepartmental coordination rather than on the creation of specific institutional structures to address trade-environment issues.

1.4.4 Where we stand

From the examination of the current situation in respect of the environmental impacts of trade, it seems clear that both thinking and practice are still in a period of development and transition.

As far as the general conceptual underpinnings are concerned, there is as yet no clear differentiation between trade and economic development in general. This is not surprising as trade is after all, a subset of economic activity. However, it may be useful, even necessary, to define in greater detail what distinguishes trade from other economic activities, and in particular, what are the implications—in environmental as opposed to purely economic terms—of the effects of the globalization of economic exchanges that trade liberalization is bringing about.

The analytical tools that exist are, on the whole, appropriate, but not yet rigorous and comprehensive enough for the task at hand. It is undoubtedly necessary to increase efforts to develop more effective approaches and analytical methods, and devise better ways of monitoring actions and gathering appropriate data. In addition, to be able to determine with more confidence what the specific effects of trade on the environment are, more studies, conducted in a more critical manner, are necessary. And finally, institutional structures need to be made more responsive to incorporating the assessment process and the results of studies into the decision-making process, thus taking a step towards effective policy integration.

1.5 Towards an Assessment Framework

Given the current situation, it might be a useful contribution to sketch out an approach that is more closely suited to addressing the issues that are specific to the analysis of trade and environment. Rather than develop a detailed methodology, using the elements that have been shown to be useful, it is our intention to outline a general assessment framework that is both comprehensive enough to cover all the various aspects involved in trade and environment interactions, and at the same time flexible enough to be adapted easily to different situations, needs and means.

1.5.1 *General characteristics of the assessment process*

The definition of the environmental assessment of trade draws on the more general definition of EIA (UNEP, 1996), and can for the purpose of our analysis be characterized as the systematic process used to predict, analyse and interpret the significant environmental impacts of trade—and related policies, agreements and activities—so as to provide information that can be used in decision making.

The objectives of an environmental assessment of trade-related issues are then, first, to provide decision makers with meaningful information on the potentially significant environmental effects of trade and trade liberalization, so that environmentally responsible choices can be made among the various options (Canadian Government, 1993); and second, to assist policy makers in the integration of trade, economic, social and environmental policies, so that together they contribute to the achievement of sustainable development.

The requirements (Kirton, 1996) to meet these objectives imply that the trade-environmental assessment framework be:

- *balanced*: Given that trade-related environmental effects can be both positive and negative, the assessment should focus on the identification of both types of effects, as well as interactions between the various factors;
- *sensitive to causal links*: The assessment should examine the nature, direction and timing of the influence exerted by trade on economic activity and environmental status; while it may not always be possible to determine unequivocally which are the causes and which the effects, attempts should be made—wherever and as far as possible—to link particular economic and ecological changes to specific and identifiable elements of trade and of the process of liberalization, including policies, agreements and activities;
- *responsive to uncertainty*: The assessment process should be flexible, so as to be able to cope with the incompleteness of the analysis caused by lack of data and the relative imperfection of predictive and modelling techniques;
- *policy oriented*: The framework should be geared to generate results that permit effective interventions to mitigate adverse effects and maximize positive ones. This suggests a shorter term focus on sectoral and geographical environmental priorities and interventions.

1.5.2 *Elements of the trade/environment assessment process*

Classical methods for environmental impact assessment (EIA) and strategic environmental assessment (SEA) follow similar paths (ECE, 1992; UNEP, 1996); these will obviously form the basis of the framework, but will be adapted to the requirements of trade-related issues. The components and stages of the assessment process, as applied to trade, should focus on the following:

- *Screening*: The initial review should decide whether a specific policy, agreement or activity connected to trade needs to be examined; generally speaking, all policies and trade agreements, without exception, should be subject to a detailed economic and environmental assessment;
- *Scoping*: The early identification of the areas or elements that need to be carefully examined should be based on specific criteria related to trade; in most cases, this will mean selection of those areas that have the potentially most significant negative environmental effects (OECD, 1993); at this stage, a decision can be made as to which type of environmental problem should be addressed and the depth of the analysis that will be carried out;

- *Proper assessment:* The areas selected at the previous stage will be subjected to a detailed analysis, determining the influences of trade on the economic activity and through it, on the environment, the causal factors that determine the impact—whether provisions related to trade policies and agreements or to internal factors such as national management practices; the breadth of the assessment will vary from the examination of purely local impacts, to regional and global ones;
- *Mitigation:* Measures to prevent, reduce and compensate for adverse impacts and to optimize positive impacts will take causal factors into account; these measures will range from regulatory approaches (e.g. modification of policies or clauses of trade agreements to incorporate stronger precautionary principles and general environmental protection measures), to technological and managerial ones (e.g. switch to clean technologies and processes, or different management practices);
- *Reporting and monitoring:* The trade-environmental impact statement should be formulated in such a manner as to allow incorporation in the decision-making process at both the regulatory and policy levels, in particular, for the modification of trade agreements or for policy integration at the national level; monitoring arrangements to ensure implementation of mitigation measures should also include provisions for monitoring the evolution of trade measures and expansion of trade-related activities.

1.5.3 Analysis of the economic implications of trade policy reforms

The economic analysis should focus on the identification of changes in the pattern and scale of the economy induced by trade and the sectors most affected. Changes attributable directly to trade may be difficult to separate from those resulting from economic development itself; similarly, it may be difficult to quantify the changes with any exactitude.

To overcome the first difficulty, it may be useful to establish simple correlations between activity in a specific sector and the degree to which there are observable or predicted changes in the scale of economic activity attributed to trade and exports. Problems in quantification can be overcome by a more qualitative analysis, using only a limited scale of characterization indicating slight increases or decreases, significant ones and no change. A system of directional arrows or other graphic signs (Harwell et al., 1994) to indicate this is useful.

In the case of an ex-ante review of an agreement, the in-depth analysis should focus primarily on those sectors that show, or are expected to show, the most noticeable change in activities after the trade policy reform takes place or after trade provisions come into force. An important factor to be considered is the time scale over which changes take place; the longer the period considered, the greater the uncertainty in the degree of accuracy.

1.5.4 Setting the stage for the environmental analysis

A necessary condition for the analysis of the various environmental effects is the definition of specific indicators which will allow the measurement of changes and environmental trends; and the establishment of a baseline environment against which to measure change.

- *Environmental indicators* used to measure trade-related effects should conform to those generally in use (Therivel, 1996), including those that measure present environmental conditions (state-of-the-environment indicators, such as levels of substance x); human impact on the environment (impact or pressure indicators, such as emissions of substance x) and whether/how various agents have carried out certain actions (action-indicators, such as percentage of plants with systems to minimize emissions of substance x). The choice of indicators (UNEP/EART, 1994; CEC, 1996) should ensure that they conform with various criteria, including those that provide a representative picture of environmental conditions and pressures related

to trade and are based on international standards to ensure acceptance and allow for comparisons. The use of environmental indicators will of course be associated with commonly used socio-economic ones of various types (e.g. describing changes in production, consumption and technological change); additional indicators needing data which is not normally collected (e.g. average energy use per unit of service/good) are also important, but may have to be dispensed with in many cases.

- *Description of the baseline environment* is essential, but there are particular problems that arise when defining a control baseline against which to measure changes in the environment attributable to trade. The pitfall is that when comparing a situation before and after the establishment of a particular trade regime, the environmental changes that normally occur over time may not be fully factored in or attributed erroneously to trade. This can, in part be avoided by using modelling approaches, but this requires making assumptions about future influences and conditions, which are at best unreliable. Given this dilemma, perhaps the most practical option is to simply combine techniques and try and reduce uncertainties in this manner.

1.5.5 Analysis of the environmental effects

The environmental analysis should focus on how the changes in the economic sectors induced by trade are translated in terms of environmental impacts; that is, the environmental implications of trade-related effects will be assessed in terms of scale, structural, product and technological effects. In addition, the various implications of the environmental effects should be examined, including:

- *Type of environmental effects* which generally include three distinct categories, namely the effects of pollution on the status and quality of the various environmental media (air, water, land); the effects on health and safety of human, animal and plant targets; and the effects related to the use of natural resources and ecosystems (OECD, 1994);
- *Scope of environmental effects* which relates to the actual reach of the effect, and can be national, transboundary or global (OECD, 1994);
- *Scale of environmental effects* which relates to three distinct aspects, including the national and aggregate scale; the sector-specific scale, and the effects related to geographic location (Masera, 1996).

1.5.6 Evaluation of the impacts and definition of corrective measures

This is the last and the most important element of the assessment proper, and involves evaluating the overall findings concerning the environmental impact of trade and trade liberalization. Among the aims is the identification of where those impacts occur in terms of spatial distribution as well as distribution among economic sectors and environmental media. The magnitude and type of effect should be evaluated, determining which is likely to have the most significant impact overall.

It is important to identify areas of environmental stress, in particular if they occur in unique ecosystems, pinpointing sensitive areas within them—the critical environmental “hot-spots”. Questions relating to the carrying capacity of ecosystems and the ultimate reversibility or irreversibility of impacts should be given specific attention. Remedial action should be designed during the evaluation phase, although implementation will take place later.

1.5.7 Further elements of the assessment framework

Other elements, including mitigation measures, monitoring and reporting, will not differ substantially in trade-related assessments from the approach applied in classical environmental assessment, and shall therefore not be dealt with here.

2. THE MINING SECTOR IN CHILE: GENERAL CONTEXT

2.1. Structure and Role of the Mining Sector

The mining sector in Chile has, over the years, played an important strategic role in the economy. The main factors that come into play are the fiscal contributions and foreign exchange it generates, its role in attracting external investments to the country and its importance for employment. However, because of the fact that most mineral production has been destined for export, and because of the high levels of investment and sophisticated technology required, the mining sector has also been responsible for a certain vulnerability in the economy and for distortions in the pattern of economic development. These drawbacks are apparent in the unbalanced growth of mining to the detriment of other economic activities, a limited creation of external economies and irregularity in fiscal contributions; there are also some problems in the generation of employment.

2.1.1 Profile of the mining sector

Mining is concentrated mostly in the northern and central parts of the country, where there is copper, iron and iodine. This area has low population densities and is characterized by mountainous relief and desert conditions which have historically precluded diversified economic activities; because of this, mining is of particular importance in these areas, constituting up to 60 per cent of economic activity. In the south of the country, mining revolves around coal, petrol and gas, but is of lesser importance economically, because of the presence of other productive sectors; overall, mining accounts for approximately 8 per cent of economic activity.

Copper is the pivot of mining activity in Chile, although iron, silver, zinc, manganese, molybdenum and lead are also important. Invariably, references to the mining sector refer in actual fact to copper mining, because of its overwhelming importance over other minerals. Almost all mineral production is exported, and historically minerals have been the largest trade item in the Chilean economy.

2.1.2 Economic contributions of the mining sector

In spite of the importance of mining for trade, the contribution of mining to the national economy is less important, being roughly 10 per cent in 1986 and 8 per cent in 1990. This decrease occurs at a time when the mining sector is expanding; annual growth in 1996 was up to 11.9 per cent, at the time (1993-1995) when the overall economy was growing at an annual average of 6.4 per cent.

Fiscal contributions from the mining sector, while important, are difficult to gauge overall. Changing conditions in the sector, in the amount of production and in prices have resulted in wide fluctuations. Available data covers only state-controlled production, which is estimated to be US\$ 18.5 million in the last 10 years. Copper production from the two main government enterprises—CODELCO and ENAMI—made up 5.7 per cent of total national fiscal contributions in 1982 and 25.1 per cent in 1989.

In 1991, Law 10.143 was enacted to regulate payments for mining concessions and exploration permits. In 1995, this item contributed US\$ 16 million (Gimpel, 1995); there is a high level of non-payment however and 40 per cent of the amounts owed (US\$ 3.670 million) are attributable to the companies that have the largest concessions.

As a means of diminishing the impact on the economy of fluctuating fiscal contributions, the Fondo de Compensación del Cobre (FCC) was created in 1985, in line with the Structural Adjustment Programme of the World Bank. The Fund is based on long-term projections of the price of copper, with a symmetrical mechanism for the deposit or withdrawal of funds from CODELCO, according to price movements. In actual fact, the Fund has been used in part to pay off the national foreign debt and to establish a fund for stabilizing petrol prices.

The mining sector is the largest single contributor to the balance of payments. Copper and copper sub-products generated an average of US\$ 920 million in 1960-1965 in foreign exchange, increasing up to US\$ 7.324 million in 1996. In 1995, of a total of US\$ 16,000 million generated by all exports, US\$ 7.850 million came from the mining sector, and, of this, US\$ 6.487 was generated by copper exports alone.

2.1.3 *Employment and labour markets*

The capacity of the mining sector to generate employment has been fairly weak, mainly because of the capital-intensive nature of production. The already low contribution to national employment by the sector has slowly decreased since the mid-1980s. Employment in the copper mining industry has remained, since the 1960s, at approximately 1.5 per cent of the total national employment and went down to 0.79 per cent in 1995—that is, 41,124 out of a total labour force of 5,174,700 (COCHILCO, 1997). In comparison, agriculture, forestry and fisheries, which account for 7.7 per cent of GDP employed 15.2 per cent of the labour force (Agacino, 1997). Overall, the mining sector accounted for 1.4 per cent of total employment in 1980; 2.2 per cent in 1986; 1.7 per cent in 1993 and 1994; 1.8 per cent in 1995 and 1996 (CEPAL, 1989; Agacino, 1997).

The trend in decreased employment is the result of globalization of the economy and the concern to develop a more rational and cost-effective production system; this has been a particularly important factor in the case of copper production, where prices for the product are generally low. Therefore, the mining companies have pursued a policy of flexible labour functions, salaries and contractual arrangements that allow adjustments according to the fluctuations of the market.

Overall, the trend is to substitute direct employment in the mines with a system of subcontracting; in 1987-1990, direct employment accounted for 56.4 million man/hours and out-sourced employment for 14.1 million man-hours; by 1991-1995 the former was down to 48.9 million man-hours and the latter was down to 13.1 million man-hours. For the workers, this has meant lack of stability in employment and salaries, but for the corporate sector, these policies have had a positive effect, as it has allowed the creation of many new small and medium enterprises specializing in the provision of services. There are no specific statistics on this type of indirect labour force connected to mining, but it is estimated that it amounts to around 220,000 individuals (SONAMI, 1996).

External contracting of accessory functions by mining companies has been, in the last few years, extended to its core functions. External contracting now covers all stages, including prospecting and determination of mineral profiles; project planning and engineering; construction of industrial installations; development of the mines; extraction of minerals; processing and treatment of the ores; and post-production activities, including transportation, shipping, insurance and marketing.

2.1.4 Public and private sector participation in mining

Both public and private sector companies operate in Chile; this list consists of large companies, many of which are multinationals, as well as medium and small ones, which tend to be national.

In 1971, during the Allende socialist administration, all large-scale mines were nationalized and in 1976, during the Pinochet military regime, the copper mines were consolidated into one large company—CODELCO; subsequently, a second state corporation—ENAMI—was created. In 1986 the Comisión Chilena del Cobre (COCHILCO) was established; among its functions is the management of administrative and budgetary affairs of the state corporations.

CODELCO—Corporación Nacional del Cobre de Chile, since its inception, has been responsible for mining development in Chile. It depends on the Ministry of Finance and Mining, its board members represent the government, the armed forces and workers. It is structured around four mining Divisions located in different areas of the country: Chuquicamata, El Salvador, Andina and El Teniente, all have attached smelters, except Andina. In addition to these operations. CODELCO is empowered by law to sell undeveloped mining concessions in its control and enter into partnerships with private sector investors and developers. It is the third largest mining company in the world (CEPAL, 1995) and in 1989 its production accounted for 13.7 per cent of world copper ; since then, because of a series of factors linked to the declining quality of the minerals, limited new exploration and the constraints derived from being a state-controlled corporation have decreased its importance at international level. It is however, still the largest mining operation in Chile—in 1994 it accounted for 26 per cent of all export earnings from mining (Birdies et al., 1994).

ENAMI—Empresa Nacional de Minería does not operate any mines, but rather, buys minerals for processing and sale. It has four processing plants, one refinery and two smelters. It has made a very original contribution to mining by fostering the modernization and development of small and medium-sized companies. In so doing, it has helped to transform production and has provided opportunities for entrepreneurs and labour through provision of technical assistance and credit and by the creation of a market for their products (Geisse, 1990). In 1994 ENAMI revenues from product sales were US\$ 841 million.

The private sector is playing an increasingly important role in mining operations in Chile. Although the sector is dominated by a few large foreign companies and multinationals, there are also various small-scale private mining operations which play an important role. In 1994, for the first time since the mines were nationalized, copper production by private companies overtook that of state-owned corporations and is expected to account for 65 per cent of production by the year 2000 (Birdies et al., 1996). Among the largest mining operations currently under way, four are operated by the private sector (Ministry of Mining, 1996).

2.1.5 Links between the mining sector and other economic sectors

The mining sector—and more specifically, copper mining—has had a progressively greater impact on the national economy, influencing increases in demand for local goods and services (CEPAL, 1989). This increase has been the result of the growth of the sector as well as of the trend—influenced by government policies—to rely on the internal market.

Government policy has varied considerably over the past decades, fluctuating between a greater or lesser emphasis on the role of the state in the mining industry, and a greater or lesser emphasis on either national industry to provide for local needs or on imports of foreign goods and services to satisfy demand. An initial phase of import substitution in the 1960s was followed by the nationalization process in the early 1970s. The subsequent redefinition of the role of the state in the mid-1970s was followed by the economic crisis in the 1980s, when there was again a sharp

turn in policies towards an emphasis on national level production and investments. Liberalization of imports and a growing competitive environment have had, overall, a positive effect on the development of local industry, driving technological innovation, increases in production and lower prices. However, because of a certain weakness in national design capacity and lack of financing and marketing know-how, the role of foreign firms and imports is still important (CEPAL, 1989).

Government statistics point to a growing decentralization in investments and closer links between the primary mining sector and industrial sectors associated with non-primary mining industries, including chemicals, basic metals, metallic products, non-electrical machinery, energy and others (Daher, 1990). The impacts are also felt in other economic sectors not directly linked with mining, such as demand for hotel accommodation, tourism and construction, as well as for consumer goods linked to the greater purchasing power of workers in the mining sector.

2.2 Internal Influences in the Process of Trade Liberalization: The Evolving Policy Framework

Since the 1930s Chile pursued a highly restrictive foreign trade regime which included, among other things, quotas and lists of items barred from importation (applying to more than 300 items), tariffs on importations (which ranged up to 105 per cent for nominal tariff rates and up to 750 per cent for *ad valorem* tariff rates); foreign exchange restrictions and application of differential foreign exchange rates (up to 1,000 per cent differential); and licences and special regimes applying to particular regions or industries (Meller, 1992; Figueroa, 1996), to name but a few of the provisions.

In the early 1970s, after the military coup, Chile adopted a neo-liberal economic policy framework, placing emphasis on opening the economy to world markets and removal of trade barriers. This had the effect of placing a larger emphasis on short-term gains; in response to these imperatives, production systems were intensified and there was a trend towards increased exploitation of natural resources, increasingly seen as the driving force in economic growth. The role of the private sector expanded as a result of the liberalization of the economy, while that of the public sector decreased. These wide-ranging policy reforms led to increased economic growth, but this growth has been at the expense of environmental quality, raising questions as to the long-term sustainability of this pattern of development. (Shurman, 1996; Scholz, 1996).

2.2.1 The overall process of trade liberalization

The strategy for trade liberalization promoted by the Chilean government was articulated in various stages, with several periods of change and reversal.

In the period 1974-1979, tariffs were progressively reduced from the previous high levels, and uneven treatment among investors was equalized. By 1979, tariffs had been reduced to a uniform 10 per cent and tariff-related barriers had been lifted. Government policy was now based on a neutral policy in favour of exports and a unilateral move towards trade liberalization.

When the Latin American debt-related economic crisis developed in the early 1980s, some changes were made in response to the challenges of the economic recession. The currency was devalued and the real exchange rate fell continuously from 1981 to 1988. In 1982, tariffs were raised up to 20 per cent, and again in 1984, to 35 per cent. In 1985 when the balance-of-payments crisis was addressed, tariffs were again reduced, first to 20 per cent in 1987, then to 15 per cent in 1988. In spite of these changes in tariffs, the main policy instrument for export expansion throughout the decade was an undervalued currency, rather than tariff reduction (French-Davis and Saez, 1995).

In the 1990s the new democratically elected government adhered to the free market policies of the previous administration, but put somewhat greater emphasis on social provisions. In 1991, continuing with the policy of liberalization, tariffs were further reduced to a uniform 11 per cent. Subsequently, trade policy moved beyond tariff reductions to a more proactive stage of bilateral and multilateral agreements. In 1996 there was a further move to reduce tariffs, but the decision was postponed in favour of a comprehensive tax reform.

Tariff reduction measures on the whole did not affect exports, but had an important impact on the components imported by the productive sectors. Liberalization created an increasingly competitive environment which spurred local industry connected to mining to reduce costs by integrating its operations. At this stage, local industry could have taken advantage of the situation, in particular the greater access to foreign technology and components, to develop further. In the event, this did not occur, and it was the foreign companies, in particular firms from the USA, which benefited from the lowered tariffs by stepping up exports and bringing the needed components into the country.

The consensus is that the impact, on the copper mining sector, of liberalization—in particular, increased trade due to lower tariffs—is relatively minor in terms of exports, imports and employment; on the other hand, trade agreements have had important dynamic effects—in particular, increased foreign investment due to the stability of the market—which are more significant.

2.2.2 *Free trade agreements*

In the 1990s, Chile completed the process of linking up to the global economy by negotiating a series of agreements and treaties with its main markets, including trading blocs and individual countries.

APEC is the most important market for Chilean copper exports in volume, accounting for 52 per cent of the total; this is a recent trend which is linked to the economic growth of its member countries. In 1990, the Asian economies consumed 3.3 million tons of refined copper; it is estimated that by 2000 consumption will increase to 5.4 million tons and by 2005 it will reach 6.3 million tons. Japan makes up 48 per cent of the consumption of the APEC countries, but it is estimated that by 2005 the relative importance of Japan will decrease as the other countries in the bloc continue to grow. Chile is in a solid position to take advantage of this situation, as its exports of refined copper went from 154,000 tons in 1985 to 614,000 tons in 1994, an amount which represents roughly half its total exports.

The European Union (EU): A framework for economic and political cooperation was signed in 1997, but it is still too soon to draw conclusions as to the effects it will have. Overall, the EU is an important trading partner, capturing approximately 27 per cent of copper-related exports alone. Fluctuation in prices in the last seven years have meant that the average growth in value of exports is minimal—only 0.1 per cent. The main countries of the EU to which Chile exported fine copper were Germany, Italy, France and Great Britain. Between 1986 and 1990, exports to all four countries increased; but in the case of Germany, exports in 1996 decreased to 1986 levels, after an increase in 1990. (COCHILCO, 1996)

MERCOSUR: An associate membership agreement between Chile and MERCOSUR was signed in 1996; the agreement reduced average weighted import tariffs levied on Chilean exports from 8.2 per cent to 3.2 per cent, and average weighted tariffs applied to imports from member countries were reduced from 8 per cent to 5.7 per cent. To date, this is possibly the most important free trade agreement signed by Chile and currently accounts for 7 per cent of copper-related exports.

NAFTA: Chile has been negotiating accession for some time, but there has been resistance to finalizing the agreement, primarily on the part of the USA. This trading bloc accounts for 10 per

cent of Chilean copper exports at present, and it is calculated (Ministry of Mining, 1994) that the integration of Chile would increase exports of copper products to a level of US\$ 10 million annually.

Bilateral trade agreements have also been signed with Canada—including an associated agreement on environmental cooperation (Annex IV)—and with other Latin American countries, including Mexico (1991), Venezuela (1993), Colombia (1993), Ecuador (1994).

2.2.3 The regulatory framework

Intervention by the government in the mining sector has fluctuated widely; a policy of minimal regulation between 1925 and 1932, when there was a regime of free trade, convertibility of currency, similar tax regimes for both national and foreign producers, and no interference in the buying and selling of mining products, gave way in the 1950s to a form of mild intervention, including exchange controls, increase in taxation and buying of mineral production by the Central Bank.

Control of mining—the most productive sector of the Chilean economy—by foreign investors has contributed, since the beginning of the century, to the development of the concept of nationalization. This thinking led, in 1971, to a modification of the Political Constitution of the State (Law 17.450) designating the government as the depository of the mineral wealth of the country; this led subsequently to the expropriation and nationalization of the copper mines.

The spirit of this constitutional change was reversed by the approval, by the military government, of the Constitutional Organic Law on Mining Concessions (LOCCM) in 1982 and of the Mining Code in 1983. These laws are unique in the Latin American legal system, and constitute one of the pillars of the extreme liberalization of the mining sector, ensuring very limited intervention by the state and protection of the rights of investors.

Private ownership of mineral deposits is established through the mechanism of *full concession*, which allows any enterprise, be it national, foreign or mixed, to acquire private control of mineral deposits, for an indefinite period, through the payment of an annual licence and with a guarantee for full indemnities in case of expropriation. In effect, the concession becomes, by its content, juridical nature, object and effects a true civil property, with all the attributes of dominion, protected by the Political Constitution of the State (CEPAL, 1994; Agacino, 1997).

Mining corporations of the State are regulated by specific provisions of the Political Constitution, the juridical framework applied to Public Enterprises, the Decree No 37 and Law No. 19.137. These regulatory instruments spell out in detail the various modalities of operations and legal requirements.

2.2.4 Regulations concerning Foreign Direct Investment (FDI)

The conjunction between the general deregulation of mining activities, and a 1974 decree with the status of law—DL-600 on the Statute of Foreign Investment—which freed up the flow of foreign direct investments, established a legal framework that was clearly supportive of the influx of foreign capital to the country. The decree safeguards investments by means of a contract between the investor and the state; guarantees the rights of the investor for the duration of the contract, provides fiscal benefits, including a favourable tax regime and the establishment of thresholds on taxes for foreign investors. It also allows offshore accounts, remittance of profits and the option of re-exporting the original investment capital after a period of three years (reduced to one year at present). Changes to the decree in 1997 have raised the minimum limit for investment capital up to US\$ 1 million, so as to avoid that speculative capitals enter the country.

An additional financial mechanism, not part of the DL-600, to come into play in the FDI is that of *conversion of debt into capital* (which involves an implicit subsidy of 46 per cent of the value of the investment). This mechanism has been responsible for up to 75 per cent of total FDI; it has been utilized mainly in the wood, paper and cellulose industry but has not played a very important role in the mining sector. Chile has also adopted provisions for controlling capital flows, including requirement for deposits in foreign currency, so as to be able to deal with the massive influx of capital, which, by 1989 amounted to 8 per cent of GDP (Velasco, 1996). Because this has a potentially destabilizing influence, the Central Bank continues to play an active role, in spite of the deregulation of the market. In the future, the end of the cycle of large investments will undoubtedly have an effect on the relative or even absolute level of investments in the country, and perhaps, on the overall economic performance.

There has been considerable controversy surrounding the tax regime applied to foreign investments, because of the various loopholes that allow to legally pay less tax than is due. As an example, one can cite the practice of multinationals to transfer debts to their Chilean corporate divisions and repatriate funds under the designation of payments of interest on the debt, which is therefore taxed at a rate of 4 per cent instead of the customary 35 per cent. There is now a growing consensus that it is necessary to further reform the tax system and ensure greater economic benefits for the country while at the same time ensuring the macroeconomic stability derived from the quality and amount of investments.

2.2.5 *The tax regime*

Tax reform is another element of the structural reforms carried out by the military regime in 1974 (Toro Rivera, 1993). The reforms affected the entire national tax system, including taxes on income, sale of goods and services and foreign trade. The main objective was to give the private sector greater prominence in the process of resource allocation and reduce distortions in decision-making caused by the tax regime. A single income tax bracket was established, so as to give all economic sectors the same treatment, and guaranteeing non-interference in the allocation of resources between sectors. The Value Added Tax (VAT) supplants the sales tax, at a level of 20 per cent, so as not to distort prices in the different sectors.

An additional reform in 1984 reduced disincentives for savings and investments, reduced progressive personal income tax and integrated personal and corporate taxes, thus avoiding double taxation on the same income. In 1989, further reforms eliminated some corporate taxes. In 1990, the civil government carried out some adjustments—with the objective of channelling more funds to the Treasury—increasing VAT from 16 per cent to 18 per cent and corporate taxes from 10 per cent to 15 per cent; these measures were strengthened by further reforms in 1993.

2.3 External Influences in the Process of Trade Liberalization: Changing World Markets

2.3.1 *Globalization and its effects on the mining sector*

The factors described above have been instrumental in the increased participation of Chile in the process of globalization; the mining sector itself has played a pivotal role in the liberalization of the market in Chile. At present, it is thought by some analysts (CEPAL, 1994) that the country is an example to other Latin American nations in this arena. Compared to its neighbours, Chile has the highest “indices” of openness, demonstrating the degree to which the economy is export-oriented.

Mobility of capital—one of the key elements of the process of globalization— has led to growing foreign investment in the mining sector. In the early 1970s, the Chilean Government had

endeavoured to attract foreign investment, but the political conditions at the time were not propitious; at the same time, the global recession and declining prices of minerals limited the amount of capital available for investment in the mining sector.

By the mid 1980s this began to change, and investments increased considerably; between 1990 and 1994 investment surged. The reasons for this change (CEPAL, 1995) were manifold, and centred partly on the situation in the emerging markets of the Latin American region—including high returns on short- and medium-term investments and less stringent environmental regulations; global factors, including technological changes improving the processing of copper and gold and the loosening of international restrictions on the floating of shares. All of these factors contributed to making international investment in mining operations attractive, with copper and gold the preferred sectors. Estimates (CEPAL, 1995) show that copper mining now absorbs around 51 per cent of global investments—some US\$ 9.540 million.

As a result of this openness to the global economy and international investment, the Chilean mining sector has become ever more dependent on the evolution of world markets.

2.3.2 Evolution of global demand, supply and prices

Global transactions in minerals are less dynamic and economic cycles have less effect on demand for minerals than in the past; this is due mainly to technological innovation, allowing more efficient use of materials and substitution of minerals with new materials. In the 1970s, transactions in minerals on global markets were 7 per cent of the total; by the 1990's, this was down to 3 per cent.

In spite of the downward trend in demand for minerals, global consumption of copper has shown a steady annual increase, particularly in the last three decades, because of increased consumption in newly industrialized countries in Asia and Latin America. There the demand for minerals went from 1.42 per cent in 1970-1980, to 1.8 per cent in 1980-1990, to 2.57 per cent in 1990-1995 (CEPAL, 1997). In 1996, the most important markets for copper were the USA (22 per cent); Japan (12 per cent); China (9 per cent); Germany (8 per cent); AND South Korea and Taiwan (5 per cent). (COCHILCO, 1996). Projections for the future (COCHILCO, 1997) indicate a probable annual increase rate of 2.88 per cent between 1995-2005, due in part to increased demand in the communications, sanitary and energy sectors.

Global copper production has maintained a fairly steady rate of annual growth, going from 1.41 per cent for mine copper and 1.54 per cent for refined copper in the 1980s, to 1.52 per cent for mine copper and 1.02 per cent for refined copper in the 1990s. There has been a degree of restructuring of the production system however, due to costs and relocation of investments. Thus, production has fallen in Zaire and Zambia and has ceased in Uganda and Japan; production in the USA shows signs of regaining ground, while production has increased substantially in Chile, and new producers have emerged in Indonesia, Papua New Guinea, Poland and Mongolia. Several countries in Latin America, including Argentina, Bolivia and Brazil have launched a process of restructuring of their mining sector which should allow them to enter world markets in the near future.

There is however, evidence of a growing imbalance between global supply and demand for copper. Projections for the period 1996-2000 for global supply of refined copper indicate an annual growth of 4.4 per cent, whereas demand is expected to grow only 3.6 per cent. This overproduction results in the lowering of prices paid for copper. Prices for copper dropped considerably between 1993 and 1995: the average price per pound in US cents went from 71.4 to 64.2 in Australia; from 60.4 to 55.1 in the USA; from 63.6 to 53.6 in Indonesia; from 54.0 to 52.0 in Peru and from 50.0 to 47.5 in Chile (CEPAL, 1995). It is estimated that in 1998, in spite of growth in demand, there will be surplus production, which will lower prices once again.

It should be noted that an important characteristic of producing countries is that they are “takers” of international prices. This is particularly so in the case of Chile, where opening up of the market has meant that private sector companies are at liberty to place their products on the market and must define the efficiency of their operations in terms not of prices, but of production costs; this in turn influences the global choice of options for investment. It is because of this that long-term planning and protection against business cycles that affect price stability are thought to be important. Decrease in prices is of limited concern to multinationals, which believe that countries with large, high quality deposits and efficient production technology—such as the case of Chile—will be able to survive drops in prices; however, it is estimated that most producers in Africa, Australia, Canada and the countries of the former Soviet Union, will be vulnerable. Given the volume of Chilean copper production, some control over prices would be possible; however, because so much of it is in the hands of multinationals, prices tend to be kept low because copper is an input into the production cycle of other enterprises owned by the same multinationals.

2.3.3 The role of Chile in international copper markets

Chile is a major global producer of copper, second only to the USA. Five of the seven most important copper mines in Latin America are located in Chile (Collahuasi, El Indio, Escondida, Chuquibambilla, El Teniente). Chilean copper production has steadily increased its contribution to international markets over the past decades. Mine copper has gone from 10.6 per cent of total world production in the 1970s, to 16.7 per cent in 1986, to 28.6 per cent in 1996; foundry copper accounts for 13.5 per cent of total world production; refined copper has doubled in the last decade, making up 18.6 per cent of the total world production (COCHILCO, 1996). By 2001, Chile is expected to account for 42 per cent of world copper production.

3. ECONOMIC EFFECTS OF TRADE LIBERALIZATION IN THE MINING SECTOR IN CHILE

3.1 Economic Evolution and Trends

3.1.1 Growth in the overall economy and in trade

Economic liberalization in Chile resulted in significant growth, including an unprecedented expansion of trade. Although much of this can be attributed to the policy reforms enacted by the government, it is also true that world economic trends played a significant role.

During the first phase of the liberalization process, from 1976 to 1979, the average annual growth rate of exports was 17.5 per cent, going from US\$ 1.2 billion to US\$ 3.6 billion. During the second phase, from 1981 to 1990, growth slowed to 7.4 per cent annually, as a consequence of the economic adjustment carried out between 1982 and 1985; exports went from US\$ 3.8 billion to 8.3 billion. Nevertheless, growth was still strong and registered an annual growth rate of 9.5 per cent up to 1995. During this overall period, global trade grew 16 per cent annually between 1975 and 1980, decreased to -1 per cent between 1981 and 1985 and then grew again by 11 per cent between 1986 and 1995 (Ffrench-Davis et al., 1995). In comparison to world trends, Chile's performance was positive. The main destination of exports (1993) was 26 per cent to countries of the European Union, 19.8 per cent to the Latin American region, 17.6 per cent to the USA, 16 per cent to Japan and 14.9 per cent to the rest of Asia.

Since 1984 Chile has also registered a significant increase in domestic production as a result of the export boom. From 1984 to 1995, the average growth rate of the economy was 6.5 per cent. Per capita incomes doubled, aided in part by the 20 per cent real appreciation of the national currency. The increase in production is even more evident during the years between 1990 and 1995, when the economy grew by an average of 8.9 per cent annually (EIU, 1996).

3.1.2 The effects of Foreign Direct Investment (FDI)

The significant increase in foreign investment in Chile has been largely a result of the legal framework established by DL-600, coupled with the economic reforms and growing confidence in the performance of Chile's economy and its political stability—in effect, Chile is considered to have a high *investment grade*.

Foreign investments in the overall Chilean economy have been somewhat variable. The annual rate of growth was of the order of 47.6 per cent in the 1950s, but declined to 6.4 per cent in the 1960's. Between 1971 and 1978 the annual rate of investments was negative, going down to -7.1 per cent as a result of nationalization of the copper mines and indemnization, which accounted for some US\$ 37 million being removed from investments (Desormeaux 1989, cited by Daher, 1990). Thereafter, investments rose continuously from 9.8 per cent of GNP in 1983 to 21.8 per cent of GNP in 1989, when it accounted for US\$ 1,139 million (Central Bank, 1992). During 1990-1993, DFI reached US\$ 1,725 million; the trend has continued and by 1995 there was an increase of 20 per cent from the previous year to US\$ 3,021 million. US\$ 410 million was interned in both 1994 and 1995 through Chapter XIV of the Central Bank's regulations on foreign exchange (a less

formal avenue than DL-600) and the figure reached US\$ 377 million in the first nine months of 1996 (EIU, 1996).

The mining sector plays a central role in capturing foreign investment, but here too, the situation has been in flux. Between 1974 and 1995, FDI materialized in mining projects was of the order of 56.2 per cent of all investments in the economy, reaching up to 70 per cent in certain years (1989 and 1994). During the years of the economic crisis of the early 1980s, investments in copper mining fell to less than 27 per cent, of which only 15.4 per cent was materialized, representing the lowest rate of investment in any sector. In 1996 FDI in copper dropped to 19.4 per cent.

It seems likely that in the long term, mining will be displaced as a preferential investment sector, giving way to investments in other sectors, and whatever funds are available will go towards maintenance and development of existing installations rather than to large new projects. An early indication of this trend is current allocation of FDI funds among registered projects, with 49.6 per cent going to services, 23.3 per cent to industry and only 9.3 per cent to mining (Agancino, 1997). Of the totals currently allocated to mining, 79 per cent went to copper, 13 per cent to gold and platinum and 8 per cent to non-metal mining, exploration, services and other items (CCC, 1996).

3.2 Economic Effects of Trade Liberalization

3.2.1 *Scale effects*

In the last decade there has been an explosive growth in exports, fuelled by increases in production by the private sector. It is quite clear that trade liberalization has played a central role in the rise in scale of mineral output and exports. Nevertheless, other factors have also come into play, namely fluctuating prices which has been countered through a strategy of raising production as a means of maintaining competitiveness.

Annual concentrated-metal production between 1990 and 1995 went from 1,588,400 to 2,488,100 tons of copper; 5,035,031 to 5,220,260 tons of iron; 656,339 to 1,041,458 tons of silver; 27,503 to 44,585 tons of gold; 25,146 to 35,403 tons of zinc; 12,450 to 20,360 tons of manganese; 13,830 to 17,889 tons of molybdenum; 1,120 to 944 tons of lead. Escondida mine alone accounts for nearly 50 per cent of the growth in copper production. In the future, it is probable that this growth will continue, as many of the mines have not yet reached their full production capacity. It is estimated that overall copper production will reach 4.8 million tons by 2001, which represents a growth rate of 10 per cent between 1996 and 2001. (COCHILCO, 1995, 1996). Exploration for new deposits has been very aggressive and has yielded good results; certain finds are of a particularly high quality, such as at Collahuasi and Lomas Bayas. This will allow further increases in production—projections show that it might reach a growth rate of 15 per cent, putting an additional 380,000 tons on the market.

3.2.2 *Structural and sectoral effects*

Changes in the relative weight of mining sector exports in relation to those from other sectors has been striking. Overall, exports grew at an annual rate of 1.7 per cent. Natural resource-based exports—including fisheries, forestry, agro-industrial products and various non-traditional products—increased exponentially, growing at an annual rate of 8.2 per cent over the period 1970-1990, as compared to the 1.7 per cent growth rate for copper-based products.

In 1970 the composition of exports was made up of 85.4 per cent minerals (75.5 per cent copper, 9.9 per cent others), 9.9 per cent forestry products 2.7 per cent agricultural products 0.1 per

cent, fish and 11 per cent other products. By 1976, mining accounted for over two thirds of total exports and between 1980 and 1990 it hovered around slightly more than half of exports. By this time, the composition of exports had changed considerably: it was made up of 55.3 per cent minerals (45.6 per cent copper, 9.7 per cent others), 11.2 per cent agricultural products, 10 per cent forestry products, 9.7 per cent fisheries products and 14.8 per cent other products (Banco de Chile, 1995). More detailed estimates (CEPAL 1989; Agacino 1997) show that the contribution of mining to total exports was of the order of 59.4 per cent (46.1 per cent for copper) in 1980; 50 per cent (41.9 per cent for copper) in 1986; 43.2 per cent (35.3 per cent for copper) in 1993; 44.7 per cent (30.6 per cent for copper) in 1994; 48.6 per cent (40.4 per cent for copper) in 1995; and 46.1 per cent (39.3 per cent for copper) in 1996.

The increasing importance of the private sector is one of the most visible effects of the influx of foreign capital. The process of trade liberalization has been the real driving force behind these changes, although government policy directed at checking the expansion of state-controlled mining has also had some influence.

The contribution of the private sector to total copper production was of the order of 15 per cent in 1972; it increased to 47.2 per cent in 1994 and reached 60.7 per cent in 1996, when the three largest companies, all of which are financed by foreign capital, accounted for 39.9 per cent of total copper production. This amount is slightly higher than production by the State, which was 39.3 per cent at that moment. The importance of the private sector is even more striking in the case of gold, where it contributes 94 per cent of production and in non-metallic substances, where its participation is nearly 100 per cent. This has been described by some authors as a *de facto* denationalization. It is estimated that by the end of the century, private sector participation—mainly foreign—will control roughly two thirds of total copper production (Agacino, 1997).

The transnational character of privatization in the copper mining sector is also very apparent, where an ever increasing number of foreign investors and multinationals are operating. Among the most important are groups from Australia, Canada, Japan, South Africa, USA (Annex V). Participation by Chilean private sector companies is smaller, mainly because of the limited amounts of capital they bring to operations; the trend is for them to enter into partnership with foreign firms which are looking for small-scale investment opportunities.

Change in the relative contributions of the large, medium and small mining enterprises has also been important. CODELCO is the only enterprise classified as large (Gran Minería, hereafter GM); private enterprises are classified under the medium (Mediana Minería, hereafter MM) and small rubrics (Pequeña Minería, hereafter PM). There is a clear decrease in the relative participation in physical production of the large mining sector (GM) and a correspondingly higher participation of the medium sector (MM), to the detriment of the small sector (PM). Between the 1987 and 1995, the physical participation of GM went from 77.2 per cent down to 46.4 per cent; that of MM increased from 20.9 per cent to 51.0 per cent; that of the PM increased slightly, from 0.5 per cent to 1.0 per cent. The largest change took place between 1990 and 1991, when the participation in physical production by GM went from 74.0 per cent to 60.7 per cent, that of MM increased from 21.3 per cent to 35.4 per cent and that of PM decreased from 2.7 per cent to 2.2 per cent. (Agacino, 1997)

3.2.3 *Technology effects*

Competitiveness in the mining sector depends on several factors, including the regulatory and financial system, the natural endowment and, what concerns us here, the technological system for the exploitation of minerals. In Chile the State has played a pivotal role in the development of the necessary physical infrastructure, including for energy, roads and port facilities, while the mining companies have been responsible for technological development in all the stages of mineral

processing. One of the main factors driving technological change and development has been the concern with reducing costs and increasing competitiveness in world markets.

In addition to the incorporation of commonly used technologies—such as satellite imaging for exploration—foreign mining companies operating in Chile have introduced a series of innovative technologies in the processing of minerals. This has allowed not only a significant reduction in costs and consequent rise in competitiveness, but has also made possible the use of deposits hitherto considered marginal. A related benefit of the widespread use of these advanced technologies is the reduction of negative environmental impacts, because of more efficient use of resources and reduced emissions and wastes. These technological innovations have been accompanied by novel approaches for management and financing and rising managerial standards.

The most important technical innovation in copper mining is extraction of minerals with solvents (SX) and electroprocessing (EW) for the production of cathodes. Between 1990 and 1995, the application of the SX-EW methods to copper production has increased fivefold. Since 1994, both CODELCO and private enterprises have used these methods. Some companies are also using various lixiviation methods, including using desalinated sea water (Lince and Manto Verde), which is very effective in areas where there are water shortages; or bacterial lixiviation (TL) (Minera Pudahuel, Cerro Colorado and Quebrada Blanca) which allows recuperation of oxidized minerals, mixed materials and secondary sulphur. Combinations of these methods have also been tested (Escondida). These techniques have revolutionized the copper mining industry, and have allowed to cut costs to one third of traditional processing costs when LIX-SX-EW systems are used together with concentration plants and smelters.

3.2.4 Product effects

Product effects are interpreted here as the changes that are taking place, as a result of the process of liberalization, in the degree of processing of exported goods. Two major trends are visible in this context and are described below.

First, in the mining sector, there has been a tendency towards exporting a somewhat higher percentage of more highly refined copper and copper products. However, the highest growth rate is in copper concentrates, which surpasses copper cathode exports. It is assumed that this may have greater environmental consequences, although no corroborating data is available. In 1975, 66.1 per cent of exports were blister and refined copper; by 1985, this had gone up to 70.2 per cent. Growth between 1986 and 1996 was striking: exports of refined copper (cathodes) went from 670,400 tons to 1,490,600 tons; blister copper went from 199,400 tons to 2,269,000 tons and concentrate went from 260,500 tons to 1,103,200 tons (COCHILCO, 1996). Projections indicate that by 2002 production of fine copper in concentrates will be around 3,300,000 tons. A direct consequence of the increased production of concentrates is the need to increase processing capacity. There is a proposal to install a smelter in Region II, capable of processing 350,000 tons of fine copper a year by the year 2001. Present capacity is only 1,530,000 tons, which is 61 per cent of production, the remaining 39 per cent must be exported to smelters outside the country; by 2002 local smelting capacity could rise to 1,695,000 tons (Chilean Mining, Oct. 1997) if the proposed plant is built.

Secondly, the government is also currently promoting export of machinery and other inputs to mining operations, mainly to Latin American countries that do not have the same mining traditions and manufacturing capacity, but are close in geographic and cultural terms. Chile's competitive advantage in this area is significant and the products have a high added value; because of this, as the sector develops in the coming years, it could become one of the most important product-related effects of trade.

3.2.5 Regulatory and policy effects

There is no clearly discernible relationship between the various regulatory and policy interventions in respect of trade liberalization and the economic effects that result. Even specific measures, such as the DL-600 and the Mining Code and other internal regulations and policies only achieved the desired effect when external conditions were favourable.

From 1975 to 1976, the effects of DL-600 on state-controlled mining are noticeable, which showed an increase of roughly 20 per cent; this levels off until around 1981 when the effects of the newly introduced Mining Code begin showing. No effects are noticeable in the private sector. Correlations with the evolution of Foreign Direct Investment also show no unequivocal effects.

4. ENVIRONMENTAL IMPACTS OF TRADE LIBERALIZATION IN THE MINING SECTOR IN CHILE

4.1 The Environmental Regulatory Framework

Chile has over two thousand laws and regulations that refer to environmental issues. These often disparate laws do not provide a coherent framework for harmonization of productive activities on the one hand and environmental protection on the other. In addition, regulatory responsibility is dispersed among various branches of government. For example, each Ministry can dictate standards through the expedient of Executive Decrees, so these remain sectoral and piecemeal interventions. In 1994, in order to remedy this situation and further develop the somewhat rudimentary system, a broad environmental legal framework was put in place, and is still in the process of development. Both sets of legal provisions are briefly reviewed here.

4.1.1 General environmental regulations

Regulations concerning air: A 1992 Supreme Decree (DS-185) regulates emissions from fixed sources of sulphur compounds (SO₂) and particulate matter (PM). Norms for arsenic are currently under study. Standards for maximum concentration of pollutants are similar to those used by USA-EPA. Applicability of the existing norms is limited to establishments that have high levels of emissions (3 tons of SO₂) and 1 ton of PM or more per day).

A two-tiered system of standards exists: basic standards regulate protection of human health and supplementary standards cover ecosystems and natural resources. The latter are applied according to a differential system based on the degree of vulnerability—e.g. stricter provisions apply in forested areas in the south, as a safeguard against damage from acid rain. Urban areas are exempt from supplementary standards.

A zonal classification system ranks areas according to prevailing air quality; provisions for individual compliance vary in each zone, so as to allow meeting an overall quality standard. Zones are classified as saturated (pollution levels are above the standard); latent (pollution is within an 80-100 per cent range of the standard); non-saturated (pollution is within a 0-80 per cent range of the standard); and not classified. Compliance is strictly regulated; there are provisions for monitoring and recording of emissions and the approval of permits and plans.

The overall system is managed by the Ministries of Health and Agriculture, through their regional services; a consultative system between these bodies and the Ministries of the Economy and Mines is also in place; decontamination plans must be approved by the President of the Republic.

Regulations concerning water: At present, the regulatory system is not very well developed, although water use and water quality standards are defined in general terms. To date, the prevailing approach has been to treat the more important interventions—such as large water management schemes or mining projects—on a case-by-case basis. There is no provision for integrated planning and management of water resources over a larger area than the project level—for example at the level of the river basin—and there are no plans to introduce something of this nature.

Existing regulations include the Chilean Norm for *water quality* (N.Ch.-1.333), which establishes physical, chemical and biological criteria for different uses, including for potable water, agriculture, leisure and aesthetics, and wildlife. However, regulations concerning water quality do not provide adequate protection—many of the legal provisions are not backed up by technical norms or standards. Responsibility for administration is not clearly assigned, and is dispersed among seven distinct bodies with overlapping functions.

Norms for emissions make a distinction between pollutant discharges in sewers and in water bodies; the 1916 Law 3.133 prohibits discharge of contaminants into drinking water supplies and applies sanctions and fines; a provisional norm regulates liquid industrial residues and wastes in water bodies. Provisional norms are expected to be overtaken by new standards according to criteria set out by the framework law.

The 1981 Water Code (article 5) establishes that water is a national good for public use; rights to use water are accorded to individuals in perpetuity and no payment is required. However, monetary transactions do take place when individuals transfer their water rights. This has created a series of problems, as it encourages waste of water and pollution; there are also many irregularities in terms of monopolistic control and speculation in water rights. Since 1992 a series of amendments have been before Congress for approval. The new dispositions call for payment for dormant water rights; the requirement to justify a petition for use of water; integrated consideration of all water endowments, including superficial and underground sources when assigning the right to use water; norms on conservation and protection. This has generated considerable controversy from those quarters wishing to see a minimum of government intervention, as well as from large consumers of water, such as the hydroelectric sector.

Regulations concerning soils: There are no specific regulations in this area, although the Ministry of Agriculture, through the National Institute for Agricultural Research (INIA) monitors areas where there are problems. A landmark case concerning sediments from particulate matter from the Huasco mine and the Potrerillos smelter resulted in the government issuing a Supreme Decree (DS-4) regulating this specific problem.

Regulations concerning flora and fauna: A National System of Areas Protected by the State was established in 1967 and covers parks, reserves and national monuments. There is a mechanism that allows to issue exploration permits within protected areas, but this is exceptional and must be approved by the President of the Republic, after consultation with CONAF, the National Forestry Commission.

Regulations specific to mining activities: A 1970 decree (D-86) of the Ministry of Mines regulates construction of tailing dams. In any case, at present, most of the facilities built by the mining companies are designed to higher standards than those required by law (Lagos, 1997). There are no standards for the decommissioning and/or rehabilitation of mining installations, but provisions are under study (personal communication, E. Oyanader, Ministry of Mining, 1997). Transport of dangerous wastes is not the subject of any regulation other than those stipulated by the 1992 Basel Convention.

4.1.2 Framework law on the environment

The 1994 *Ley de Bases del Medio Ambiente* (Law 19.300), or basic law on the environment, is directed, in the first instance, towards ensuring effective coordination of environmental decision-making at all levels.

The law establishes two levels of institutional structures for this purpose: CONAMA—the National Commission on the Environment—which has as its main task the coordination and promotion of cooperation among all government bodies concerned with environmental issues. COREMAs—the Regional Environmental Commissions—are the operational authority for environment; their principal function is to administer the system for environmental impact assessment. In addi-

tion to a Regional Director and four counsellors, these bodies gather representatives from various government departments, including the Ministries for Economy, Public Works, Agriculture, National Patrimony, Health, Mining, Housing and Urban Planning, Transport, Telecommunications, and Planning and Cooperation.

The more important elements of the framework law include:

A system of environmental impact assessment (SEIA): this is similar to that applied in many other countries. Projects to which application of SEIA is mandatory include mining, coal, petroleum and gas projects. Although SEIA was established in 1994, its application remained voluntary, but has, since 1997, become mandatory.

In general, under the SEIA, only an Environmental Impact Statement (DIA) is called for; however, if the project has important environmental implications—in line with criteria described in Article 11 of Law 19.300—an Environmental Impact Assessment (EIA) is required. EIAs are contracted and paid for by the proponent and carried out by an accredited body, such as a University. COREMA is responsible for reviewing and approving the study. In addition to description of the project and its effects, the requirement is to present plans for measures directed to the mitigation, correction, reparation and/or compensation of environmental problems. There is also a system for monitoring relevant environmental variables; in those cases where no national guidelines or standards exist, international ones are applied.

A weakness of the SEIA lies in the lack of explicit definition of terms of reference and scope, leading either to restrictive or overly detailed studies, based on the personal decision of a government official; the fact that EIA is not a definitive step in implementation, and other permits may be required, is a weakness that is of particular relevance for mining projects (García & Solari, 1995). Other problems include the fact that a system for environmental insurance is not contemplated, nor is there provision for funds for management of the actual closure of projects nor thereafter.

Public participation in the SEIA is enshrined in the framework law, and allows citizens to post observations on projects and submit appeals to public authorities. However, in contradiction to this provision, the law also stipulates that this type of recourse shall not affect the decision which is being appealed (Article 29). Experience shows that participation usually comes too late and there are no structures to deal with conflicts over controversial projects. To date, delays have occurred in respect of hydroelectric and industrial projects, but no mining project has been contested.

Environmental norms: The basic law provides general guidelines for development of norms applying to water, air and soils. A 1995 provision establishes the modalities for the formulation of these norms, including technical and economic analysis, scientific studies, consultation with competent public and private sector bodies and dissemination of information to the public. Norms are to be re-examined every five years, according to the same procedure.

At present, two types of norms exist, regulating environmental quality and permissible levels of emissions. Quality-related norms are defined as primary or secondary, according to the degree to which they affect human health. Primary-quality norms have national validity, whereas secondary-quality norms and emission norms apply only at the regional level. Norms regulating emission of liquid industrial wastes into water bodies are currently being developed and will affect mining operations.

Management plans are an integral requirement of the framework law and are proving to be a useful mechanism for ensuring a broader system of environmental protection. The main reason for this is that at present they deal with issues that are not covered by other laws, including protection of water courses, soil, landscapes and wildlife species. Government authorities can demand

development and implementation of these plans from developers and users of natural resources in the areas they administer.

Prevention and correction: The provisions of the basic law are interesting in that they allow use of a variety of novel instruments as a means of ensuring that preventive and corrective measures are implemented, including legal and financial instruments (e.g. tradable permits, taxes on emissions, charges to users). This is in line with similar provisions operating in developed countries.

4.1.3 Influences on the development of environmental regulations

Trade liberalization, the pressures of the market and the need to comply with international standards has had a significant influence on the Chilean Government in the development of environmental legislation. More specifically, this influence has operated in several different ways.

Perhaps the most significant of these has been the example set by foreign companies operating in Chile, and which has acted as a stimulus for the development of national legislation. These companies are often subsidiaries of multinational companies that operate according to high environmental performance standards; the Chilean divisions have tended to apply the same procedures and technologies as those used internationally. In many cases, these provisions are more stringent than those required by Chilean law. A case in point is the application by Exxon of environmental standards from the parent company to its operations in Chile.

Other factors, such as repeated pressures (1978, 1984, 1989) by the United States Government to introduce more appropriate environmental regulation has also had an effect. After the US Government had decided to decrease imports of copper products because of low environmental standards in Chile, companies operating in Chile independently adopted standards compatible with those of the US EPA.

Finally, there has been the indirect pressure of public opinion, influenced in part by developments in other countries. This is illustrated by the case of citizens suing CODELCO for contaminating the Bay of Chañaral; a sentence was passed by the Supreme Court in their favour, setting a legal precedent.

More recent developments, such as the signing of a bilateral Agreement on Environmental Cooperation between Canada and Chile (Annex IV) will continue to influence development of both environmental legislation and management plans.

4.1.4 Application of the environmental regulatory framework

In the early stages of development of environmental regulations—before the provisions of the basic environmental law came into force—there was a tacit understanding between the government and industry, in particular the mining industry, that international norms for the protection of the environment would continue to be applied by them.

There is now growing evidence that the application of the regulatory framework in a systematic manner, rather than reliance on a purely voluntary approach, is beginning to have an effect. There has been an increment in the EIAs carried out than in the past. The mining industry has spearheaded this movement. For example, between 1990 and 1995 mining companies carried out 56 EIAs—approximately 50 per cent of the total (Ibacache, 1995)—as compared with 27 by the energy sector, 17 each by the construction and forestry industries, eight by the agricultural sector and three by the livestock industry. (Leal, 1997).

Application of mitigation and corrective measures are on the increase. Five important examples concern the decontamination plans at state-controlled mines, including CODELCO at Chuquicamata, Potrerillos and Caletones, and ENAMI at Hernán Videla Lira /Paipote and Ventanas (Annex VI). These plans are carefully monitored and regularly controlled for performance. Implementation of broad management plans is also on the rise (Annex VII), mainly in the private sector. Finally, there is also evidence that emissions have decreased considerably, partly as a result of environmental regulation coming into force.

There is still much to be done to refine environmental regulation in Chile, in particular the approval of pending regulations and the development of new elements to fill in the gaps in existing regulations. There is also a need for more leadership, a global vision and greater co-ordination.

4.2 Environmental Impacts of Mining

4.2.1 *The phases of the mining process*

Each phase of the mining process involves specific activities that have a greater or lesser effect on the environment. These generic types of impact lead to the more specific environmental impacts that are presently occurring in the mining sector in Chile. Understanding what each phase entails helps to understand where and how environmental pressures occur.

Exploration and development: The initial exploration phase covers large areas and involves satellite imaging, geological mapping, geomechanical and superficial geological sampling. This is carried out with small equipment; environmental impacts are unlikely in this phase, and if they occur, are easily remedied. More in-depth exploration covers a smaller area and involves drilling, digging of trenches and building access roads. Environmental impacts may be significant, but can be mitigated later by general rehabilitation and revegetation of the area. Only 10 per cent of areas where deposits are found are eventually developed (Eggert, 1994)—this gives an idea of the magnitude of the problem. During the development phase, installations including infrastructure and processing plants, are built. Environmental impacts may be serious—depending on the size of the installation and the building techniques used—but less so than those associated with later stages.

Exploitation: This phase involves extraction of ores through superficial trenches that cause geological and visual disfigurement. Mining operations generate dust particles as a result of dynamiting, crushing, loading and transportation of ores. It should be noted that most minerals occur in low concentrations—for example, copper is usually present in a ratio of 1 per cent weight; this gives an indication of the enormous amounts of materials that must be processed to extract the pure metal. At this stage, impacts arise mainly from solid residues, which do not necessarily cause serious problems, except, possibly, aesthetic impacts. Water interacting with the residues may give rise to acid waters (sulphuric acid) that can contaminate drinking water and surrounding ecosystems. This is the most serious impact in this phase; however, the alkaline nature of Chilean soils acts, to a certain degree, as a buffer against acid emissions, both in water courses and air (Lagos & Velasco, 1994). Underground mines usually produce less residues than open-pit mines. Overall, the nature and magnitude of environmental damage will depend on the type of mineral, the extraction techniques and environmental management practices employed, as well as other factors such as climate and location in relation to settlements.

Processing: Extraction of metals can be done in three ways, or by a combination of methods, depending on the type and specific characteristics of the mineral being extracted. Hydrometallurgical processing, uses liquids and lixiviation with sulphuric acid. Pyrometallurgy uses dry processing at temperatures between 100°C and 3,000°C and includes calcination and fusion; associated emissions of sulphur compounds, particulate matter and arsenic cause the most significant environmental impacts. Electrometallurgical processing uses electricity to separate metals from the other associated materials. Technological developments, using modified converters (developed in

Chile) and flash ovens (developed in Finland) allow an integrated processing that significantly reduces emissions and energy use. The environmental impacts of this phase revolve around the generation of solid residues (various solids, acidic sludge and toxic residues); liquid residues (acidic water, tailings); emissions of gas (particulate matter, toxic and reactive gases) and noise.

Closure and rehabilitation: Underground mines are usually sealed; surface mines undergo a process of rehabilitation, regrading, stabilization and revegetation. Environmental problems in this phase include acid leaching and subsidence, as well as aesthetic impacts. There is still little experience in this area, as few mines have actually been closed.

4.2.2 Current environmental impacts of copper mining in Chile

Recent studies on the environmental impacts of the copper mining sector (Pagani et al. 1992 and 1994; Lagos and Velasco, 1994; Ecología y Desarrollo, 1995; Quiroga y Van Hauwermeiren, 1996; Lagos, 1997) show a variety of serious problems. Among the most important are the following:

Exhaustion of non-renewable resources: The main environmental impact of copper mining is the eventual exhaustion of the resource. At present, because of improvements in exploration and exploitation techniques, known copper reserves are still very high, and in no immediate danger of exhaustion—it is estimated that reserves may last for another 48-100 years. The inevitable effect is therefore still to come.

Air pollution: The main components of emissions from copper mining that affect the quality of air are sulphur compounds, arsenic and particulate matter, released mainly in pyrometallurgical processing in smelters. Over the last few years, emissions have decreased due to improved technology and the putting in place of plans to reduce emissions and pollution (Annex VI).

In 1989, emissions of SO₂ from the copper mining sector accounted for 93.4 per cent of all emissions in Chile. Smelters accounted for 91 per cent (874.4 tons/day) and roasting plants for 2.4 per cent (22.9 ton/day) (Pagani et al., 1992). Total sulphur emissions from the seven largest smelters in Chile (Chuquicamata, Caletones, Potrerillos, Ventanas, Paipote, Chagres and Refimet) amounted to 986,195 ton/day in 1990; 947,192 in 1991; 933,100 ton/day in 1992, and 910.639 in 1993. (Personal communication; L. Olcay, Ministry of Mining, 1997). Emissions of arsenic accounted for a total of 4 ton/day in 1988, and 2 ton/day in 1992, although these estimates are based on partial information only (Arteaga y Durán, 1994).

Overuse of water resources and pollution: The main problem in terms of *water use* is the competition for scarce resources, in particular in the northern regions where most of the mines are located. At present, enough water is available, but projections indicate that in future, demand may be greater than the available supply. The case of Region II is illustrative of the type of conflicts that can arise between various users. Water use in the mining sector was 15 per cent of available resources at the beginning of the 1990s, and it is estimated that this will rise to 35 per cent in 2000; agriculture uses 60 per cent of available resources, which leaves limited amounts for other uses.

Information on *water pollution* is not available, but studies carried out at the end of the 1980s and early 1990s—based on data from the previous decade (Lagos and Velasco, 1994)—in the Copiapó (Region III), Elqui (Region IV), Mapocho (Metropolitan Region) and Aconcagua (Region V) rivers suggest that water quality standards were exceeded on occasion due to effluents from nearby mines, although without serious effects. The main pollutants are suspended solids which cause turbidity, metals (lead, copper, mercury, molybdenum, arsenic and nitrates) which cause high acidity, and percolation of processing residues, which cause variations in water salinity; this last can be a serious problem. At present, the large mines produce minimal amounts of effluents, because of the processing techniques employed; this however is not the case in smaller mines.

Soil contamination: Information on contamination of soils—either by direct deposition of substances or indirectly through leaching—is not readily available. Because mines are located in areas of low population density, whatever pollution occurs has gone largely unnoticed. In any case, it is likely that at least acid pollution is largely neutralized by the alkaline soil.

Known instances of pollution include sulphur and arsenic emissions from the Paipote smelter, which affect nearby vineyards; particulate matter and toxic gases from the iron pellet plant of Huasco, which has affected olive groves to such an extent that, in 1992 the Chilean Supreme Court of Justice ordered a decontamination plan to be undertaken; emissions of particulate matter from the Chagres smelter may be affecting surrounding agricultural land; particulate matter, sulphur compounds and arsenic depositions from the Ventanas smelter, as well as the nearby thermo-electric plant, also are affecting surrounding agricultural land.

Land use changes and subsidence phenomena are not a problem in the copper mining sector.

Decrease in species: To date, there has been only a negligible impact on flora or fauna, because most mines are located in the desert, where there are few species. This could well change in the future, as more areas are explored. Recently, exploration has been approved in the ecologically interesting and vulnerable Andean ecosystem; there is also a case of exploration in a protected area, which was removed from the system for this purpose.

Environmental risks associated with abandoned mining sites: The main concern are residues remaining in tailing dams and waste disposal sites after the closure of a mine. In the past, there have been some serious incidents, such as that which occurred in 1965, when the installations at El Cobre collapsed, killing 220 people, or 1987 when the Perez Caldera installations nearly overflowed. At present, there are 717 tailing dams with liquid wastes and 149 sites with solid wastes; 299 are unstable, and have a degree of leaching into water courses; an indeterminate amount of these installations have been abandoned (Lagos y Velasco, 1994). Most of the mines currently operating have an expected life of 8-30 years, so that additional problems are not expected to arise until they are decommissioned.

4.2.3 Factors influencing environmental impacts in the mining sector

On the basis of available information—which is indeed very limited—it would seem that the most important environmental problems arising as a result of mining activities are connected to air and water pollution. But an important question is to determine the causal factors involved. Ultimate causes of, and responsibility for, environmental impacts are very difficult to determine unequivocally.

The *large mining companies*, which manage the major projects and process upwards of 10,000 ton/day (Annex V), because of the volume of production, are likely to cause more damage. However, because they employ more advanced technologies and management practices in all phases of the mining process, they produce a smaller degree of unit/impact, although overall impacts are still significant.

The situation of *medium mining operations* is somewhat different. Older installations have a significant unit/impact, in spite of the small volume of production, due to the use of inappropriate and antiquated technology. More recent installations, pressured by market forces as well as regulation, are incorporating advanced technologies and management methods, which will reduce the magnitude of the unit/impact.

The 2,000 *small installations* that are operating at present—mostly gold mines processing less than 200 ton/day—have not yet incorporated modern technologies and environmental management practices; they also have little managerial capacity and access to credit, which suggests that the environmental problems that arise from these operations are likely to continue for some

time. However, because these operations are widely dispersed and are so small, they only account for very localized impacts.

Present mitigation measures (Annex VI) appear to be fairly limited in terms of the companies involved, although this is changing, as more and more companies take action to protect the environment. From the evidence, it would seem as if environmental management by larger companies is thorough and reasonably effective (Annex VII).

4.3 The Mining Sector and Environmental Problems in Chile

The environmental problems caused by mining activities must be seen in the context of Chile's natural environment, as well as in relation to national and regional environmental problems.

4.3.1 Geographic Profile

Chile is located on the southern Pacific coast of South America. It is 4,352 km long, and has an area of 756,946 km². Topographical and climatic conditions vary considerably. The rainless northern desert gives way gradually to a Mediterranean type climate in the central region and then to a temperate climate with high precipitation in the south. The north is well endowed with mineral deposits, the central and southern zones provide good conditions for agriculture and forestry and coastal fisheries are abundant. Population, is 13.8 million (85 per cent urban); the most densely inhabited areas are the Metropolitan Region (5.3 million), Region VIII (1.7 million) and the Region V (1.4 million). The northern areas, where most of the mines are located, are sparsely populated.

4.3.2 National level environmental problems

Below is a brief review of the main environmental problems affecting Chile over the national territory; those connected to the mining sector are highlighted where they occur, giving an indication of the role it plays in the overall environmental problems of the nation.

Air pollution: This affects urban areas, mainly the capital Santiago. Pollutants include suspended particulate matter (from dirt roads, diesel engines), carbon monoxide and nitrous oxides (from vehicles) and sulphur oxides (from industry). Non-urban areas are affected by pollution from mining, as well as from cellulose and fish meal processing plants. Pollutants include sulphur dioxide, arsenic and nitrous oxides. Overall SO₂ from fixed sources exceeded 900,000 tons in 1989, coming from copper smelters (91 per cent), roasting plants (2.4 per cent), thermoelectric plants (5.2 per cent) and petrol refineries (1.4 per cent).

Water pollution: Microbiological contamination of water is a serious problem caused by inadequate treatment of wastes from both domestic and industrial sources. This affects rivers and coastal waters adjacent to urban centers; pollution of groundwater is an emerging issue. Industrial effluents from copper mining, cellulose and fish processing plants are also a serious problem.

Land and soil deterioration: Desertification, erosion and soil deterioration are the most important problems; causes are linked to local environmental conditions, climate, and the lack of appropriate management practices. Desertification affects approximately 33 million ha and is estimated to be increasing by 300,000 ha/year. Erosion and loss of soil fertility occur throughout the agricultural areas and are estimated to be increasing at a rate of 40,000 ha/year. Overall estimates of the percentage of land affected vary between 50 per cent and 70 per cent of the national territory.

Endangered species and habitats: Chile does not have a high number of species, those that occur are characterized by a high level of endemism; ecosystem diversity is relatively high. Approximately 8.3 per cent of the 4,758 plant species are endangered. Fauna is also threatened—overall 50 taxa are endangered, 93 are vulnerable and 53 are rare; 52 out of a total of 91 mammal species are also endangered. Freshwater fish are endangered by pollution and introduction of exotic species; marine species are threatened by over-exploitation. Ecosystem deterioration is prevalent, and although 17.5 per cent of the national territory is designated as protected, and it has been suggested that additional protection is necessary for around 80 sites.

4.3.3 Regional environmental problems

The relationship between regional environmental problems and problems connected to the mining sector are even more obvious than at the national level. It should be noted however that only areas where mining activities are located have been described. There has been an attempt to rank the importance and/or severity of the regional environmental problems; here, the top ten problems are taken as the base range. (Sources: Hayek et al., 1990; Ecology y Desarrollo, 1995)

Region I—Tarapacá: Pollution caused by fish processing plants is a problem near urban areas; water shortages and water losses because of bad management practices and inadequate infrastructure is the most serious problem related to water, followed by pollution caused by the fishing industry. Rivers contain high levels of natural pollutants. Eight of the first 10 problems ranked are related to water management, three to the fishing industry.

Region II—Antofagasta: Air pollution is a serious problem and is caused by industry, traditional mining and the metallurgical sector as well as by energy generation. Water is contaminated with naturally occurring boron and arsenic; fluorides and nickel are also prevalent. Soil over a 2,000 ha area is contaminated by the Chuquicamata smelter. Eight of the first 10 problems ranked are related to water management and industrial air pollution.

Region III—Atacama: Air pollution is caused by traditional mining, metallurgy and energy generation. Water pollution is associated mainly with boron, but iron and fluorides are also present. Soil contamination from the Paipote copper smelter and the Huasco iron pellet plant affects 3,200 ha. Four of the first 10 problems ranked relate to water management.

Region IV—Coquimbo: The main problem is pollution of water with copper, boron, arsenic and iron coming from the ore deposits in the area. Ecosystem deterioration by dryland agriculture and by mining and industrial activities is also a problem. Three of the first 10 problems ranked are connected with water management.

Metropolitan Region: Air pollution is serious and is caused mainly by transportation and industry located around the capital. Water pollution is also important. Soil contamination by mines and cement plants affects around 5,000 ha. The first 10 problems ranked are connected to water pollution by domestic and industrial wastes, air pollution from fixed and mobile sources and waste disposal.

Region V—Valparaíso: Local air pollution and acid rain is caused by copper smelters and a petroleum refinery. Water pollution from copper and iron mining discharges are a problem. Soil contamination is associated with the smelters at Ventanas and Chagres (15,000 ha) and the Melon cement plant (4,000 ha). Four of the first 10 problems ranked are connected to water management.

Region VI—Libertador General Bernardo O'Higgins: Problems are related to lack of urban planning and poor infrastructure. There are concerns about copper contamination in soil, and sulphate and molybdenum pollution from the Teniente mine; 30,000 ha are affected by pollution from the Caletones foundry.

4.3.4 Influence of mining activities on overall environmental problems

Considering the evidence, it is clear that mining activities have a significant influence on environmental problems at the national level. However, in terms of population affected, the environmental impacts of mining have lesser importance than desertification, erosion, urban growth and water pollution from waste water (Lagos, 1997). Mining activities accounted for 92 per cent of the sulphur emissions (Regions II-III); 5 per cent of the water use and for a significant amount of water pollution; contamination with copper is the most serious problem connected to soil pollution at the national level (González, 1994).

At the regional level, the environmental impact caused by mining activities is even more striking. It is clear that in Regions II, III and IV, environmental problems are caused principally by copper mining. A more detailed analysis shows that air pollution caused by smelters and water pollution are a problem in Regions II, III, V and VI; water pollution is a problem in Region IV and water use is a problem in Regions II and III.

4.4 Environmental Effects of Trade Liberalization

4.4.1 Evaluating the evidence and establishing links

The economic effects of trade liberalization in Chile have been significant. The scale of the economy has increased and there have been changes in the structure of the economy itself, with a move to greater diversification of activities; these changes have also brought about a shift in the types of products that are being exported. Transfer of technology, particularly in the mining sector, has been facilitated by trade liberalization; at the same time, the new technologies that have entered the country have affected the manner in which the mining sector operates. Finally, regulatory and policy factors have both fostered the process of liberalization and subsequently been influenced by liberalization itself.

Environmental impacts occur during the various phases of mining and affect air, water, soils, biota and ecosystems; these impacts also have significant regional and national significance.

Applying the hypothesis of the assessment framework, the question is: to what extent is it possible to link the economic changes that have taken place as a result of trade liberalization with the environmental impacts that are clearly visible? Put another way, it is necessary to determine the environmental effect that trade liberalization has had, or is having.

For the purpose of the analysis, trade liberalization is understood in its broadest sense—going beyond issues such as trade agreements and lifting of trade barriers—to encompass the overall process of opening up of the Chilean economy to world markets, the internal factors that caused and strengthened this, and indeed, the evolving ideas on the nature of the economy.

While quantitative evaluation of the effects of trade on the environment is impossible here, it is certainly possible to make a qualitative assessment, based on the data presented earlier. But, in the end, it is difficult to state categorically whether the overall effect has been positive or negative in environmental terms.

What is clear is that there is a very complex interplay of economic and environmental effects, and each type of effect is linked with various factors and conditioned by them. Thus, effects of scale are mitigated by technology; structural and product effects are intertwined, and regulation and policy influence, are in turn influenced by, the other effects. In the analysis below, only the environmental aspects will be examined, but it is understood that there are various economic and social elements that come into play, both in terms of present as well as future effects of trade on the environment.

4.4.2 *Scale effects*

It is obvious from looking at scale effects in isolation from technology, product and other effects that as mining activities expand environmental impacts increase. Even though in the Chilean case there have been technological advances that have tended to reduce environmental impacts (see “Technology effects”) caused by the new production, there will still be effects from increased mining production. Growth in exports will continue to rise as trade and global economic exchanges develop further. Consideration of scale effects in isolation in the case where virtually the total stock of minerals is exported shows that the link between trade and environmental impacts is unequivocal.

In purely environmental terms, trade liberalization has led directly to two distinct types of effect. First, there is the inevitable depletion of non-renewable mineral resources. While the extent of known reserves has increased due to more effective exploration methods, it is also true that some of the mines—for example, Chuquicamata—are beginning to see the effects of a declining resource. As efforts are made to offset decline in production by more intensive exploration and the opening of new mines, it is likely that environmental impacts will also increase.

From a regional perspective, export-led growth in mining activities has had extensive and pervasive effects in the north of the country, where most of the mines are located. Although detailed data are not available, it would appear that there may, in future, be particularly serious and long-term damages to unique ecosystems in the high mountain plateau (altiplano). This is an area of global significance, among other things, because it is the habitat of the Andean flamingo.

4.4.3 *Structural effects*

Chile’s comparative advantage has been, and continues to be, based on natural resources; since the beginning of the century, trade patterns which have mainly focused on minerals have reflected this. As a result of trade liberalization, exports have diversified considerably, moving away from non-renewable minerals towards renewable natural resources.

The environmental effects of this diversification and shift towards renewable natural resources is not well documented, but there seems to be an emerging tendency towards an unsustainable pattern of exploitation. This concerns not only the eventual collapse of some resources through exploitative pressure (e.g. fisheries) but also generalized pressure on the ecosystem, including pollution, erosion, desertification and loss of habitats and species. Thus, the shift from non-renewable mineral resources can be considered as generally positive, but the long-term environmental viability of exporting renewables will depend on various factors extraneous to trade itself.

In addition to structural changes within the larger economic arena, there have also been structural changes within the mining sector itself. There has been a shift away from State-controlled companies, towards the private sector, made up mainly by multinational companies, although smaller local companies also are playing a role. The effects that this has on the environment are not very clear, but it would appear that, because of greater managerial capacity and access to international-level technologies, the multinational companies are likely to manage environmental impact more effectively; this is offset however, by the scale of their operations.

4.4.4 *Technology effects*

Trade has had direct and clearly identifiable effect on technological factors. It has allowed the transfer of environmentally sound and ‘clean’ technologies. Most of the technologies in question concern the exploitation and processing phases of mining, but also, to a lesser extent, fall into

other categories. There has been a related transfer of environmental management methods as well as broader managerial skills.

Both technologies and management practices are being applied on an increasingly large scale and are already having beneficial effects on the environment. The evidence shows that pollution originating in the mining sector is steadily decreasing in terms of loads per unit of output; efficiency in the direct use of resources has also increased, both in terms of the ratio of minerals extracted from ores as well as in terms of resources used for processing, such as water, chemicals and energy. Recycling is also increasingly common.

At present, it is mostly the large mining companies that have applied improved technologies and management methods, but there is evidence of this spreading to medium and small companies, which will eventually contribute to diminishing the overall negative effects of mining.

There are no studies indicating the spill-over effect of technology transfer from the mining sector to other sectors of the Chilean economy, but it is likely that this may be occurring; if not now, then in the future. One case in point is the use of desalinization technology, which has clear application in various other industrial sectors and can contribute significantly to conservation of freshwater resources.

4.4.5 *Product-related effects*

As a result of changes in demand in international markets, there has been a noticeable shift in the types of products exported, both at the level of the economy as a whole, as well as within the mining sector itself. In terms of copper exports, there is a greater emphasis on concentrates, rather than refined copper. The relative proportion of each product has changed dramatically, with export of concentrates increasing 375.2 per cent since 1990.

It is difficult to judge the environmental effect of this product shift, because it has been accompanied by growth in absolute terms. In addition, the degree of environmental impact of concentrates varies according to the nature of the ores and type of processing technology used, rather than being a fixed effect. As there is such variation in both factors, it is not possible to determine in an unequivocal manner what the overall environmental effect of this shift in product exports is.

However, it would seem that, in environmental terms, the focus on concentrates is more benign, because smelting is avoided. What is certain is that improved pyrometallurgical and hydrometallurgical technology is contributing to reduce the environmental impact of concentrates per unit of output, thereby offsetting to some degree increases in the scale of production.

4.4.6 *Regulatory and policy effects*

The process of economic and trade liberalization has had a significant influence on the development of environmental regulations, management practices and policy in Chile. In the 1980s environment was still accorded low priority by the Chilean Government, but because of external influences as well as direct pressure from trading partners, this has begun to change.

There has been a move to rationalize existing environmental legislation and modernize the system by introducing new regulations and procedures. Broader environmental management procedures are being influenced to a significant degree by the practices introduced by large foreign companies operating in the mining sector and conform to international environmental standards. Chile's continuing emphasis on liberalization indicates that a market-based approach to environmental protection is emerging as the preferred management route.

Environmental issues are also now becoming part of the political agenda and have even been the focus of agreements for international co-operation on environmental matters, as part of trade agreements.

4.4.7 *Effects on environmental media*

It would be useful to have a precise indication of the net effects of trade on the various environmental media. However, because of lack of data, the dynamic nature of both the causal factors and effects, and the presence of countervailing forces, this is not really possible.

Correlation of various categories of economic effect and related causal factors operating in the mining sector allow to assess the effects on environmental media, using a simple scale to measure the degree of the impact (Borregaard, Blanco and Wautiez, 1997). But overall only an approximate picture of the present situation emerges:

- *Effects on mineral resources:* In the long term, the overall effect will be severely negative: exhaustion of the resource; in this particular case, the associated economic and social effects of an unsustainable activity are also severe;
- *Effects on air:* The overall effect appears negative, although increases in pressure are being offset by improved technology;
- *Effects on water:* The overall effect on water quality appears mildly negative; the effect on water availability appears negative; in both cases, increases in pressure are being offset by improved technology;
- *Effects on soil:* The overall effect appears mildly negative and localized; increases in pressure are being offset by improved technology;
- *Effects on ecosystems and biota:* From the scant data available, the overall effect appears mildly negative and localized; pressures may increase in future;

5. LEARNING FROM EXPERIENCE

5.1 The Assessment Process

5.1.1 The question of relevant data

Assessing the environmental impacts of trade liberalization has been a novel undertaking in the context of Chile. Although there are studies concerning the economic dimension of the mining sector as well as its importance for trade, environmental aspects have not been dealt with before in this manner.

A serious difficulty encountered in carrying out this task has been the lack of relevant data. In spite of the fact that all possible sources were tapped, including government and industry reports, bibliographic compendiums, the research literature, written questionnaires and personal interviews, very little was obtained.

Economic data are comprehensive and readily available; however, they are not in a form amenable to interpretation in terms of environmental issues. Data on the mining sector—on production, extraction and processing, technology and management—was accessible but not really relevant to the task at hand. The real difficulty was with environmental data, which were extremely limited. What is most striking is the nature of the data that is available—most refers to pollutants, presented in the form of point/source pressures; but there seems to be no information on the effects of these pressures—that is, the actual environmental impacts. In the absence of baseline data on the state of resources and ecosystems; in the absence of adequate monitoring to record changes in these systems as the result of human induced pressures, there is no basis for understanding how the environment is affected or is changing as a result of economic activity or trade.

In these conditions, the case study analysis was very difficult. The question is now, how to overcome the problem until such time when data become readily available. There are, unfortunately, no ready answers—for the moment, improvisation in the way data are gathered and analysed is probably inevitable.

5.1.2 Application of the Trade-Environment Assessment Framework to the Chilean case

The study in Chile was used to test the applicability and usefulness of the proposed Trade-Environment Assessment Framework. Because of time and resource constraints, it was used as a means of organizing the existing data ex-post facto, rather than as an instrument for shaping a research and evaluation programme.

As expected, the most pervasive difficulty was the blurring between the overall effects of economic activity and the specific effects of trade. Establishing robust causal links was also difficult, but this was mainly due to the lack of information already alluded to, rather than to methodological problems.

Specific methodological difficulties encountered concerned the analytical categories. Their discrete application, focusing on one element at a time was not wholly productive, resulting in considerable overlap between the economic, trade and environmental analysis, as well as between the

categories concerning effects. This has led to iteration of the findings rather than allowing new insights.

A related issue was the difficulty in distinguishing between positive and negative effects. For example, economic effects were often associated with environmental effects which balanced each other out, making it difficult to arrive at an unequivocal assessment; new technologies (technology effect) have had on the whole, a beneficial environmental impact, but these same technologies have allowed massive increases in production (scale effect), which in itself has negative impacts. Disentangling the different causes and effects was simply not possible.

Finally, the analysis did not allow the full complexity of the environmental impacts to be reflected. This was partly a function of the unavailability of data, and also because the framework itself did not seem to lend itself readily to including other elements, even though this is recognized by it as an important part of the approach.

5.1.3 Refining the Assessment Framework

The insights gained here may allow to fine-tune the approach embodied in the Assessment Framework, so as to deal with the difficulties encountered in its application to a real situation. Many of the problems had, in any case, already been identified as possible stumbling blocks when the approach was developed. Below are suggestions on how some of the difficulties may be overcome.

Focusing on a qualitative, selective and in-depth analysis: Given that availability of data will always be a problem, a frankly qualitative focus on selected and representative items, analysed in depth, is probably the best option at present. A thorough understanding of how environmental systems work coupled with an analysis based on deduction, inference and extrapolation can go a long way in helping to understand what is happening. This is not 'settling for second best'; on the contrary, with such complex phenomena as those that concern us here, it is probably more useful to reflect on the issues, rather than draw faulty conclusions from imperfect data.

Application of analytical categories: Difficulties encountered in applying the various categories of effects to the analysis can be overcome by being more flexible. Rather than considering them as fixed categories that occur in all cases, they should be considered as *possible but not necessary effects*. Thus, they should serve as a backdrop to assist consideration of the issues, rather than as obligatory steps in the analysis.

Focusing on the interaction of systems: In order to overcome the tendency towards overlap and iteration, it would be useful to consider all the elements of the analysis together as an *interacting system*, rather than as separate (albeit linked) elements to be reviewed in a sequential manner. Thus, instead of studying each type of process separately, it would be helpful to carry out a multi-dimensional matrix analysis, considering economic, social and environmental systems on the one hand and effect categories on the other, simultaneously. Such a complex analysis will necessarily focus on qualitative interactions, as suggested above, rather than attempt quantification. Even if the techniques for this type of analysis are not well developed, it is probable that results would be more illuminating than sequential analysis and more robust than in the case of quantification with little reliable data.

Focusing on the dynamic nature of environmental impacts: Considering the *dynamic interactions* between the various types of pressure—the manner in which environmental pressures act together and result in synergistic and cumulative effects over time and space—can help to give a clearer idea of the complexity and real nature of environmental impacts. Other elements that can be analyzed selectively include local, regional and global effects; effects on ecosystems rather than single environmental media; considering the entire life cycle of processes or products, from the

extractive/ productive stage, to distribution, use, disposal and possible recycling. Here again, a multidimensional matrix system can be useful.

The overall focus: In order to overcome the basic difficulty of distinguishing between the effects of economic development and the effects of trade, it might be better to modify the focus of the analysis slightly. Rather than emphasizing the need to determine the links between trade and environmental impact, it might be more productive to accept the overall influence of trade on the economy as a given; as both are inextricably linked, it is not clear that they can, or even should be separated. It would then be possible to focus more deliberately on the *mechanisms* at work—that is, the economic mechanisms mediated by trade—that are causing environmental impacts. We should not ask *whether* trade is a causal factor in environmental impacts, but rather *how and why* this occurs. In this manner, the levers of policy intervention are made clear.

Cooperative approaches to the assessment process and an interdisciplinary focus can help overcome skewed perspectives (as occur when the analysis is done from a preponderantly economic or environmental point of view), as well as the problems linked to lack of data. Involving the main stakeholders—local communities, research institutions, the public and private sector—brings to bear their accumulated knowledge and various points of view, needs and capabilities; it also makes subsequent action possible because it engages people through participation.

5.2 Lessons from the Mining Sector in Chile

5.2.1 *The Chilean experience*

The introduction of neo-liberal policies in Chile in the early 1970s was accompanied by deliberate moves to lessen the role of the state, create a favourable climate for private investment, open up the economy and increase trade exchanges. This process coincided, internationally, with an overall expansion of the world economy and increasing globalization.

This conjunction led to a remarkable growth in the Chilean economy, fuelled to a great extent by exploitation of natural resources at an ever increasing rate. This has affected the quality of the environment and even raises questions as to the long-term sustainability of this pattern of economic development.

Following this process through the case of the Chilean mining sector, it is possible to establish a chain of causal events that have led to the current impacts on the environment:

- The process of economic liberalization in Chile resulted in the opening up to world markets and a freeing of trade and economic exchanges; this in turn resulted in a marked growth in exports in the mining sector;
- Increased trade, in turn, resulted in structural changes in the mining sector as well as in a shift in production patterns and changes in the type of products exported;
- Scale effects resulting in great part from trade, contributed to increasing environmental pressure which, in terms of waste disposal, site abandonment, social and economic sustainability of mining communities and water scarcity is a significant concern;
- External factors—e.g., the lobbying of the United States copper producers not to allow Chilean copper in their market, in terms of environmental dumping, or the pressure by multinational companies on the Chilean authorities to obtain clear environmental regulations—have played a significant role in environmental management in the Chilean mining sector and have influenced the manner in which these impacts were perceived and dealt with, spurring the government to set in place a regulatory framework to address environmental impacts;

- At the same time, trade liberalization also encouraged transfer of more environmentally effective management practices and technologies to deal with the emerging environmental impacts;
- Improved environmental regulation, management and technologies are allowing, and in future will continue to allow, reduction of the negative environmental effects of mining activities per unit of production, thereby offsetting at least part of the effects of growth;
- Although the information available makes an overall environmental balance difficult, the increase in production and trade of mining products is responsible for the following negative impacts and concerns: waste disposal (especially solid waste), social and economic sustainability of mining communities, water scarcity, site abandonment; environmental progress, on the other hand, has been achieved with respect to air and water quality; and,
- Ultimately, because the mining sector is based on a non-renewable resource, its activities will be greatly reduced and then cease; abandonment of mining sites may leave a legacy of residual environmental problems.

This step-by-step review of the findings of the study shows clearly that trade liberalization has indeed had an important and negative environmental impact, but that countervailing forces—also directly linked to the liberalization process—are contributing to their mitigation.

5.2.2 *Managing the environmental effects of trade*

Experience in Chile shows that, to date, the most effective way of addressing the environmental impacts of mining activities has been through regulation and improved technology. Although both factors are operating reasonably well, there is room for further improvement and for specific actions to support and extend the beneficial influences.

It is therefore suggested that additional measures be undertaken, principally by the government, although the private sector can also make a significant contribution to their implementation. Only the main categories of activities that should be addressed will be suggested here.

Environmental policy framework: It would be desirable to develop an explicit policy framework to deal with environmental issues, that would give purpose and direction to the various initiatives and provisions that currently exist. Among the main elements that should be considered is the introduction of a long-term perspective to development policy and the integration of economic, social and environmental elements within it. This framework should inform government activities, including legally binding agreements connected to trade—for example, when negotiating the proposed accession of Chile to NAFTA.

Environmental planning and management: Going beyond the current approach to environmental protection that focuses principally on point intervention and regulation, the introduction of a broad system of regional planning and management, covering entire ecosystems or river basins, would allow to deal with the interactions between different environmental pressures and the competing demands of economic sectors more effectively. This approach would also make systematic collection of data on the environment and monitoring changes over time feasible.

Environmental regulatory framework: It is desirable to rationalize both the regulatory system as well as the associated institutional structures. As part of this move, a comprehensive set of norms and standards for environmental quality should be developed, including not only the present thresholds on pollutants, but also indicators of ecosystem integrity and status of biota and habitats.

Development and transfer of technology: These two elements have been shown to be the most effective means of integrating environmental protection with economic activity. Setting in place explicit provisions to encourage this to take place at a larger scale, both within the mining

sector as well as throughout the economy, would contribute to enhancing environmental protection.

Specific action programmes: The development of a strategy to ensure the transition towards a more sustainable pattern of development in mining areas should be seen as a priority. This would entail exploring development of other forms of economic activity that do not rely solely on non-renewable resources. Other supportive actions could be to undertake studies on how to address the historically accumulated impacts of mining and issues of similar strategic importance.

Financing of environmental protection: This could be secured by the creation of a fund specifically for this purpose. The mechanisms employed to build up the fund will depend on many factors, but possible options include reform of the tax regime and direct contributions by the mining sector.

5.2.3 *Understanding the implications of trade liberalization*

Having examined the effects on the environment of trade liberalization, it might be useful to reflect on the broader implications. Is it possible to extend the same kind of analysis to the overall effects of trade liberalization in the mining sector on Chilean society as a whole? What is the nature of these effects? Are they, on balance, positive or negative? It might appear a rhetorical question, because trade liberalization is undoubtedly beneficial—but in what circumstances, at what price?

Based on the experience in the mining sector, we might frame some questions. Trade liberalization has undeniably influenced the direction and growth of the Chilean economy. But how has the overall economy benefited? How much has trade served to stimulate national internal growth and employment? How much has it contributed to the welfare of Chileans? What are the long-term prospects for the country? What is the long-term significance of the growing dependence on foreign investment and foreign ownership of productive resources?

These points apply to the case of the mining sector in Chile. But it would seem that there is a more general mechanism of cause and effect at work, which applies not only to other economic sectors, but to the overall economy of Chile, and of other countries as well.

These questions need to be addressed primarily as a means of pinpointing weaknesses and identifying where effects might be negative in the long term. Only then will it be possible to manage the process of trade liberalization so that it can truly benefit the country, and people, rather than the global economy—that somewhat elusive entity of ever moving investment and profit that feeds on itself.

5.3 **Looking to the Future: Towards an Improved Policy Framework**

5.3.1 *Addressing effects of trade*

It seems clear that trade liberalization has a series of effects that need to be examined. It is useful to understand what the specific effects are—on the environment, on the economy, on the social fabric of countries. But these factors also need to be considered as a system.

To date, the tendency has been to focus on trade principally from the economic point of view. This is natural, in that trade is after all an economic activity. But we know that this economic activity has far reaching consequences that affect both social and environmental factors. Thus, the practice of giving primacy to the economic dimension of trade, and, in the best of circumstances, dealing with the other effects in side agreements, no longer seems desirable.

If we consider the many cases when the economic dimension of trade has been given primacy over social considerations (as in the case of the WTO ruling against the EU's ban on hormone-treated beef) or the environment (as in the GATT ruling on tuna import restrictions), we see that this approach is ultimately self-defeating.

If we accept that the economy is an instrument to promote human welfare, not an end in itself, then this imbalance between the weight accorded to the different dimensions of trade needs to be redressed.

5.3.2 *Moving towards policy integration*

It is becoming increasingly recognized that it is necessary to integrate the various dimension of development—including trade. Efforts towards greater policy integration are already under way, but need to be extended and applied more vigorously.

A deterrent to progress in this endeavour is the complexity of integrating the disparate elements in a world that is organized along sectoral lines. All levels of human endeavour, and all stages of decision-making are sectoral. The current approach is to try and achieve integration at the level of action by trying to reach a balance among competing interests and needs, all of which are legitimate within their own bounds. Often, none is served adequately, or the strongest sector has primacy. This is what is happening at present, where economic factors are acquiring an ever growing influence over all other aspects of society.

A way to address this dilemma may be to integrate the various interests and needs at the initial stage of policy formulation—that is, where goals are defined. At this level, goals should refer to the overall goals of society—not to the narrow, purely sectoral ones. The problem is that these very broad goals are seldom defined explicitly—they constitute the unspoken direction of society. But because they are not explicit, because they are not defined in a stringent manner, they are often overlooked, and indeed, society inadvertently moves counter to them.

Recognizing this problem, it would seem possible to state these broad goals explicitly, and from there to devise a broad strategy—the focus of the actions of society. From there, it is possible to devise an integrated policy framework that gives a balanced direction to sectoral policies. It is not the place here to describe all the intricate steps towards putting such a framework in place. Indeed, there is abundant advice as to how this must be done. Just to name one instance, Agenda 21, the internationally recognized strategy for sustainable development, outlines such a framework, most notably when describing the means to integrate environment and development in decision-making (Chapter 9).

This framework should also inform trade policy, and steps need to be taken to ensure, on a global level, that trade agreements are truly balanced and not favouring one need against another. The steps towards this are perhaps complex, but certainly clear. What is lacking, is the collective will to reach balance. Recognizing this is the first step to achieving this balance.

ANNEXES

ANNEX I

ASSESSMENT OF THE EFFECTS OF TRADE ON THE ENVIRONMENT: CURRENT ANALYTICAL TOOLS

A variety of analytical methods and approaches are currently being employed to assess the effects of trade on the environment. As is apparent from this brief review, most are not structured nor formal methodologies, but are primarily ad hoc approaches.

1. Application of Environmental Impact Assessment Methodologies to Trade

To date, no trade-specific methodology has been developed; most of the stages of classic Environmental Impact Assessment (EIA) and Strategic Environmental Assessment (SEA) have been directly transferred and adapted to the examination of trade-environment relationships. A combination technique has been used in some cases, such as that developed by the North-South Center of the University of Miami (Harwell et al., 1994). The assessment is organized on the basis of qualitative ranking of known environmental risks; it catalogues known ecosystem types and their locations, connects important economic sectors to affected ecosystem and extrapolates information from data on the changes in economic sectors already known to be occurring in the wake of liberalization of trade. The method is based on the scenario-consequence approach and progresses through four stages, using the results of each previous scenario:

- *Trade scenario*: Identification of the potential changes in the trade regime between countries engaged in the liberalization process and modifications in the structure of imports and exports;
- *Economic sector scenario*: Estimation of the changes in economic activity in a country as the result of trade;
- *Stress scenario*: Estimation of the magnitude and type of environmental effects and risks induced by economic change;
- *Trade/environment impact assessment*: Estimation of the impacts on ecosystems, both with and without additional environmental controls being imposed on the critical ecosystem components, as measured by the stress scenario;

2. Macro-Modelling Approaches for Identifying Environmental Impact

Economic modelling is used in many of the current studies, including models for economic assessment, environmental assessment or a combination of both; this last category includes specific trade-environment models. Macro-economic models are also being used to identify indirect effects of trade liberalization. Examples include the Global Trade Analysis Project (GTAP), a general equilibrium (GE) model and the computable equilibrium (CGE) model. Environmental assessment models have been developed to identify correlations between economic variables and environmental effects by using environmental data sets that are absent in economic models. However, most of these models do not provide information specific to trade, as they tend to focus on environmental problems (e.g. climate change). The combination of models has permitted development of sophisticated analytical tools. The OECD TEQUILA model (Trade and Environmental Equilibrium Analysis model) is based on a dynamic, multisectoral CGE model to assess how trade liberalization and changes in production processes affect emissions of different pollutants.

3. Focus on the Effects on Growth Resulting from Trade Liberalization

The 'environmental Kuznets curve' (EKC)—the hypothesis which postulates an inverted U-relationship between environmental improvement and growth—is being applied to analyse the effects of trade liberalization. This approach attempts to show that economic growth is not a threat to global sustainability, and that it alone might solve the problems of environmental degradation (Beckerman, 1995).

4. Focus on Specialization in Pollution-Intensive Industries

This approach, based on econometric methods, examines the structural effects of freer trade and investigates whether there is a direct causal link between trade liberalization and specialization in pollution-intensive activities, leading to higher levels of environmental deterioration.

5. Focus on National Level Effects

The various national studies, although focusing on the same general issue, are concerned with differing economic and environmental domestic conditions and distinct policies, regulations and enforcement. Most have been carried out on a case-by-case basis, using a variety of ad hoc methodologies, including combinations of various well known methods. Because of this lack of uniformity, it is not possible to compare them.

6. Methods Used to Review Trade Agreements

Governmental reviews of trade agreements and policies generally are qualitative rather than quantitative and are intended primarily as a means of alerting policy makers in advance of the environmental consequences of proposed trade measures. A uniform methodology does not exist, but each review has interesting elements:

The EC Commission approach to the environmental review of the Single European Act (SEA) (EC Commission, 1990) focuses on the sectoral and spatial distribution of environmental impacts generated by economic activity linked to the European Internal Market. Existing macro-economic modelling is used to quantify growth in pollution, but it is recognized that the uncertainties inherent in economic and environmental modelling do not allow precise quantification of impacts.

The US approach to the review of NAFTA includes application of alternative economic scenarios followed by assessment of environmental effects; quantification is only applied to air pollution.

The Canadian approach to the review of NAFTA focuses on analysis of the environmental provisions of the agreement; assessment of their impact on Canada's environment; review of potential mitigation processes and follow-up mechanisms. Screening for potential environmental effects includes: global and atmospheric issues; air and water; renewable and non-renewable resources; toxic substances and waste management.

The US approach to the review of the Uruguay Round of Agreements (URA) focuses on how environmental considerations were taken into account in the URA negotiations; assesses the possible effects on US laws and regulations, as well as on the US environment and on economic sectors such as agriculture, transport and energy. The approach pinpoints the difficulty of assessing and quantifying impacts stemming from the economic changes spearheaded by trade liberalization.

The Canadian approach to the review of URA focuses on the policy and regulatory implications that the agreement will have for Canada and identifies the extent to which it is consistent with Canadian government goals for environmental protection and promotion of sustainable development. This is done on an agreement-by-agreement basis, describing the treaty provisions and then assessing potential environmental implications. Among the issues raised is the need to consider environmental impacts not only at the national and regional levels but also at the global level, particularly for problems such as ozone depletion, climate change and loss of biodiversity.

The Dutch approach to the review of URA (Kuik, 1996) focuses on the potential conflicts between the agreement and the national and international environmental policy of the Netherlands. Areas exam-

ined include precautionary approaches in relation to product standards and regulations; ecolabelling and life-cycle requirements for products; and climate change policy.

7. Guidelines for Assessing the Effects of Trade on the Environment

The OECD *Procedural Guidelines on Trade and Environment* (1993) were developed as a standard approach for use by member States. Procedural aspects of the assessment process are defined; in terms of methodology, no specific approach is recommended, but available options are listed, including environmental assessment (EIA), forecasting models, scenario evaluation, case studies and policy evaluation techniques such as Cost-Benefit Analysis (CBA).

ANNEX II

ENVIRONMENTAL IMPACT OF TRADE LIBERALIZATION: REVIEW OF THE EMPIRICAL EVIDENCE

Below are highlights of the results of various studies undertaken to assess the environmental impacts of trade liberalization.

1. Results of Application of Models to Assess the Effects of Trade on the Environment

Modelling of NAFTA's effect on Mexico's environment: The study indicates potential increases in real GDP of 3.2 per cent accompanied by an increase of 2.8-4.8 per cent in all major pollutants. It was shown that, in the absence of appropriate environmental policies, freer trade induces negative scale effects in all sectors. The study also suggests that the introduction of pollution abatement taxes would achieve a reduction in effluents. Overall, the negative effects of growth were shown to be small.

Modelling applied to the case of Chile: Three policy scenarios are considered against a reference, business-as-usual scenario. The first scenario imposes taxes on pollutants, one at a time; the second considers gradual trade liberalization accompanied by a modest improvement in the terms of trade; the third combines the first two, analysing coordinated trade and environmental reforms. (Beghin et al., 1996). The findings are that unilateral trade liberalization, in the absence of environmental policies, induces higher growth and patterns of specialization that are damaging to the environment. The study also shows that pollutant-specific taxes have unintended and damaging consequences on emissions of 'substitute' substances.

2. Results of Cross-Country Studies

Below are examples of two distinct types of cross-country studies, focusing on growth-induced changes on the one hand and specialization in polluting industries on the other.

Analysis of the relationship between national income gains, trade and environmental quality: Two separate studies examined the impacts of NAFTA and the links between economic growth and the environment (Grossman and Krueger, 1992, 1995). The relationship between ambient air quality and per-capita income in a set of between 50 and 120 cities in developed and developing countries was examined, regressing indicators on SO₂ levels and suspended particulates against a set of independent variables, including GDP per capita, national trade intensity, population density and others. The conclusions of these studies suggest that pollution intensity is generally higher in the early stages of industrialization and subsequently decreases as incomes rise, but it is acknowledged that the correlation between income growth and environmental protection is not automatic. Similar conclusions were reached in an OECD study (Beghin, Roland-Host, and van der Mensbrugge, 1994).

Analysis of the relationship between income growth and indicators of environmental quality: A study (Shafik and Bandyopadhyay, 1992) covering the period 1960-1990 in 149 countries, examined 10 separate indicators including for air and water quality, waste disposal, emission levels and resource degradation. The findings show that both wastes and emissions unambiguously rise with rising incomes.

Analysis of the Kuznets curve for carbon dioxide emissions: A study (Holty-Eakin and Seldan, 1995) of 130 countries covering the period 1951-1986 found that levels of emissions start to decrease at income levels (US\$ 35,000 per capita, in 1986 values) that are far higher than those found in most countries and suggest a great difficulty in reaching reductions of CO₂ emissions.

Analysis of the relationship between the rate of growth of pollution and the level of environmental degradation: In a study (Birdsall and Wheeler, 1992) covering 25 Latin American countries over the period 1960-1988, econometric methods were used to analyse the relationship between the rate of growth of pollution intensity, per capita income, and the degree of openness of the domestic economy to international trade. It was found that, in the 1980s the higher the degree of openness of the economy, the higher the reduction in pollution. It was estimated that switching from a fully closed to a fully open economy would probably reduce growth in pollution from 35.1 per cent to 4.7 per cent per annum. For the 1970's, the impact was similar.

Analysis of the environmental impact of trade liberalization in the Latin American and Caribbean Region (LAC): The study (Ruge et al., 1997) reviewed changes in national and regional trade policies in the LAC region over the last 30 years and assessed the resulting sectoral economic and environmental impacts. The releases of 14 categories of pollutants were related to production and exports of eight major industrial sectors in the 16 countries of the region; this data was correlated to exports, to determine the related pollution. The study showed that there is no clear link between growth in exports and intensity of pollution: export-focused industry showed a slight trend towards sectors with a lower pollution intensity, but at the same time, pollution-intensive sectors expanded in response to export demand. Overall, the study shows that positive structural effects are accompanied by scale, product, technology and regulatory effects and that freer trade is likely to put pressure on environmental resources. The researchers concluded that the analysis did not explain the actual dynamics of the effects of trade liberalization and implementation of environmental policies.

3. Results of National Level Studies

A number of national studies have been carried out, many of which have been done since 1993 by UNCTAD/UNDP. For the most part they focus on the possible effects of environmental requirements for exports or the environmental implications of outward looking policies. An interesting case is that of Poland, discussed below; other studies include those in Argentina, Bolivia, Brazil, Chile, China, Colombia, Costa Rica, India, the Philippines, Turkey and Zimbabwe.

The case of Poland: The study focuses on the market reforms that have been central to the economic changes in the recent period of transition (Fiodor et al., 1994). When assessing the environmental impact, no distinction was made between these general reforms and trade liberalization. The study shows that as prices were liberalized internally and trade shifted towards a decentralized pattern, Poland specialized in exports of pollution-intensive goods and environmental damage resulted.

The case of Venezuela: The study (Harwell et al., 1994) assesses the range of environmental effects resulting from the free trade agreement with the United States. Twenty major economic sectors were considered in the context of three scenarios of no free trade and free trade with and without environmental side-agreements. The study concluded that export sectors—except those with an inherent competitive advantage—might be affected by stringent environmental requirements; changes in the economy were expected to be followed by adverse environmental effects in various high-risk areas including habitats, biological diversity and climate. In some cases (e.g. habitat damage) environmental impacts could be reduced, but in the case of species depletion, the prospects for reducing adverse impacts appeared low. Overall, the study showed that a free trade agreement would expand the existing process of growth, including associated environmental impacts and that those impacts could be mitigated through the instrument of an environmental side-agreement.

The case of Colombia: The study (Gaviria et al., 1994) examined the relationship between pollution intensity and international competitiveness, but no significant correlations were found except in products such as textiles, leather, wood products and refined petroleum. Trends in average pollution intensity over periods differing from each other in terms of trade regime were also examined; the conclusion was that industrial pollution appeared to be independent from trade policy. Significant environmental effects associated with export expansion in primary products were identified. Coffee is a clear case where international market forces shaped the nature of the production process and where the environmental impact has been justified on economic grounds.

4. Results of Governmental Reviews of Trade Agreements

Various reviews have been conducted, either of a specific agreement, or studies of the same agreement by different countries.

4.1 *Environmental review of the Single European Act (SEA)*

The review (EC Commission, 1990) identified various economic sectors where environmental effects resulting from the European Internal Market were likely to be significant: energy, transport, tourism, the manufacturing industry (including micro-electronics, textiles, chemicals and pharmaceuticals) and agriculture (including food processing). Among the more important findings was the likelihood that SO₂ and NO_x would increase, by the year 2010, by 8-9 per cent and 12-14 per cent respectively, above the levels reached in the absence of the Internal Market. It is suggested that legislative and technological changes would not be sufficient to offset the effects of projected growth, and that structural changes in the transport sector would be necessary. An important spatial component to the distribution of environmental impacts was also suggested: serious problems may arise in peripheral regions and traditional industrial regions (TIR) unless established European level management measures are complied with. The conclusion of the study is that in the absence of an adequate framework to stimulate the further decoupling of economic growth and pollution and the use of ecological thresholds as the basic reference for policies, there is no guarantee that the growth of the Internal Market is likely to be sustainable and lead to an increase in welfare (EC Commission, 1990).

4.2 *Review of the North American Free Trade Agreement (NAFTA)*

The US review identifies some areas of concern where environmental impacts might be important; among these are the United States-Mexico border areas, where fragile semi-arid ecosystems are already under stress; the question of water supply and quality, and correlated problems of solid and hazardous waste management. Another area where pressure might increase is for wildlife and endangered species. The report concludes that, overall, short-term negative environmental effects would be offset by longer-term beneficial ones and that NAFTA would be positive for environmental quality, whereas the opposite would be the case if it did not to enter into force.

The Canadian review identifies vulnerable spots; for water quality, it concludes that chemical contamination from industrial sources, particularly in the Great Lakes region is of concern, but that NAFTA would not have a significant influence on increases nor would it hamper remedial action. It is expected that NAFTA will leverage growth in forestry, but that this will have negligible environmental effects, including on wildlife and habitats. Important transboundary problems such as long-range transport of persistent organic pollutants are expected to persist, irrespective of NAFTA and it is suggested that cooperation in monitoring and research on their control would be useful. Increase in trade with Mexico, given the overall modest volume, is not expected to have measurable effects. On balance, the conclusion was that NAFTA would be largely positive.

4.3 *Review of the Uruguay Round of Agreements (URA)*

The US review concludes that the URA will increase economic activity worldwide, and that growth will generate the resources necessary to address environmental concerns. It is estimated that global allocative efficiency in ecosystem-based activities—such as agriculture—will increase, thus reducing adverse environmental effects. Technological change is identified as a crucial factor in determining the ultimate environmental impact of increased economic activity, particularly for sectors such as the transport and energy sectors.

The Canadian review contains many references to the positive growth, scale, structural and regulatory effects of trade liberalization. The review concludes—without really substantiating the claims—that the URA will promote more efficient allocation and use of resources, increase production and incomes and lessen pressures on the environment.

The Dutch review, although somewhat speculative, singles out areas where it is believed that there may be conflict between national legislation and WTO provisions and recommends that an international environmental code be developed to deal with the issue.

ANNEX III

INSTITUTIONAL ARRANGEMENTS FOR ENVIRONMENTAL ASSESSMENT OF TRADE

Below are examples of national procedures and institutional structures to deal with environmental issues, including the assessment of the effects on the environment of trade policies and trade-related activities.

Australia: Full reviews of proposals and submissions related to trade and environment policies are a requirement. Before these reviews go to Cabinet, they are discussed through a system of inter-departmental cooperation at the level of Ministries and Departments.

Belgium: Responsibility for trade and environment policies are dispersed among federal and regional departments and coordination is required. To date, no reviews have been carried out, as Belgium believes that this should be done by the European Union.

Canada: A Cabinet directive requires that all federal departments and agencies apply a non-legislated environmental assessment to policies and programmes submitted to it for consideration. In 1993 a Task Force on Trade and Environment was established to provide advice; it is composed of representatives from the environmental, business and academic communities.

Finland: At the administrative level, there is a coordination agreement between the Ministries of Trade and Industry and of Environment. In 1992 a national Advisory Expert Group was established; it is composed of government officials, representatives from industry and NGOs. To date, no formal reviews have been carried out.

France: To date, no formal procedures exist, and the government is undertaking a research programme (1997-1998) to develop an assessment methodology and framework.

The Netherlands: There is no requirement for trade policy to be the subject of environmental review; policy integration is based on inter-departmental consultation. To date, studies on the effects of trade agreements (e.g., of the Uruguay Round of Agreements) have been carried out.

Norway: Policy integration relies on coordination and cooperation between departments dealing with trade and environment; an inter-ministerial 'core group' made up by members from Foreign Affairs and the Ministry of Environment has been set up. In 1992 a 'national reference group', acting as an advisory body, was established.

Sweden: There is a formal requirement for all legal decisions (such as agreements on trade) to be the subject of an environmental impact assessment before approval. Policy integration is carried out by a small group of officials within the Trade Department of the Ministry for Foreign Affairs and the Ministry of Environment; there is also an interministerial working group made up of all ministries interested in trade and environment issues. A 'Reference Group' made up of representatives of the government, industry and NGOs meets regularly to exchange views and provide inputs to the government.

Switzerland: The Federal Government requires consultation between agencies proposing policies or legislation and interested parties in the private sector. Environmental reviews (e.g. of the Uruguay Round of Agreements) have been carried as a collaborative effort between economic and environmental departments of the government and independent experts.

United Kingdom: In 1992, the Department of Environment issued a guide on 'Political Appraisal and the Environment' to assist civil servants in integrating environmental issues in policy making, including. To date, no specific review of trade policies has been undertaken.

United States: The National Environment Policy Act (NEPA) requires that an Environmental Impact Statement be prepared for all major federal initiatives affecting the quality of the human environment; under this provision, assessments of trade agreements have been prepared. In 1994 a Trade and Environment Policy Advisory Committee (TEPAC) was established to provide advise to the United States Trade Representative's Office and the EPA.

Going somewhat beyond the strictly national scope, but affecting national level procedures, one can mention that the *European Commission* requires screening all of its actions for significant environmental impacts. However, no formal environmental assessment process is required, leaving the approach flexible, with each department (directorate) free to choose a position, after consultation with the Environment Directorate. To date, no specific guidelines have been developed for trade-related issues.

ANNEX IV

AGREEMENTS ON ENVIRONMENTAL COOPERATION BETWEEN CHILE AND CANADA

Chile and Canada have embarked on a process of trade negotiations, in view of the future accession of Chile to NAFTA. As part of this process, a series of documents have been signed, including the Canada-Chile Free Trade Agreement (CCFTA), as well as a Memorandum of Understanding on Environmental Co-operation and the Canada-Chile Agreement on Environmental Cooperation (CCAEC), which entered into force in June 1997.

This last is patterned on the North American Agreement on Environmental Cooperation. Both documents concerning environmental issues define the parameters within which trade exchanges will take place and also detail the areas of specific cooperation between both Governments. It will also prepare the way for Chile to initiate a process of institutional, managerial and technological change.

The *Memorandum of Understanding on Environmental Cooperation* describes, among other things, transfer of technology as well as of management practices concerning natural resources. Specific topics include mining, water management, forestry, protection and conservation of biodiversity, as well as the application of environmental impact assessment (EIA) and the use of economic instruments for the purpose of environmental management.

The *Canada-Chile Agreement on Environmental Cooperation* includes commitments on the part of both countries to enhance environmental cooperation and enforce environmental laws and regulations governing air, water, toxic substances, wildlife and others. The agreement covers 160 laws and stipulates that any changes that need to be done will be phased in over a two-year period. This clause was inserted specifically because Chile has a considerable number of obsolete laws which should be repealed, and also does not yet have effective enforcement provisions.

Citizens and non-governmental organizations will be able to make submissions in cases where they believe that governments have failed to effectively enforce environmental laws. These submissions will be evaluated by an independent dispute resolution panel. Fines will be levied if the government in question fails to implement actions called for by the panel. The level of these fines shall not exceed US\$ 10 million; this is lower than the similar provision in NAFTA, and reflects the reduced volume of trade between Chile and Canada.

ANNEX V

MAJOR FOREIGN INVESTMENT PROJECTS IN THE MINING SECTOR IN CHILE

(Source: COCHILCO, 1996)

<i>Project</i>	<i>Investors</i>	<i>Estimated total investment (in million US\$)</i>	<i>Phase</i>	<i>Production</i>	<i>Start</i>
I REGION					
Cerro Colorado (extension)	Río Cerro Inc., Canada Río Chile Inc., Canada (subsidiaries Río Algom)	198	Operating and Extension studied	Copper Cathodes/ actual 58,000 ton/year Copper Cathodes/ proj. 40,000 ton/year	1999
Collahuasi	Falconbridge- Canada Minirco- Luxemburg Mitsui Group- Japan	1,760	Construction	Copper in Concentrates: 330,000 ton/ year Copper Cathodes 50,000 ton/year	1998-1999
II REGION					
El Abra	CODELCO- Chile Cyprus Amax- USA	1,050	Operating	Copper Cathodes 225,000 ton/ year	1996
Tuina	Yuma Copper Corp. Canada	30	Study	Copper Cathodes 12,000 ton/year	1999
Leonor/Tesoro	Equatorial Treasure Ltd., Australia Grupo Luk- sic—Chile	220	Study	Copper Cathodes 60,000 ton/year	1999
Lomas Bayas	Gibraltar Mines Ltd., Canada (Westmin Resources Ltd., Canada)	246	Construction	Copper Cathodes 60,000 ton/year	1998

<i>Project</i>	<i>Investors</i>	<i>Estimated total investment (in million US\$)</i>	<i>Phase</i>	<i>Production</i>	<i>Start</i>
Mantos Blancos	Anglo-American Group, South Africa	137	Operating	Copper Cathodes 31,500 ton/year Copper in Concentrate 46,000 ton/year	1996
Fundición La Negra	American Barric, Canada Noranda Inc. Canada Others—Chile	58	Operating & in expansion	Blister Copper 180,000 ton/year Sulphuric Acid 278,000 ton/year	1997
Aguas Blancas	Teslin Químicas de Chile Inc., Canada Atacama Chemicals Co. Canada	6969	Financing	Iodine: 1,000 ton/year Sodium Sulphate 150,000 ton/year Potassium Nitrate 70,000 ton/year	1998
El Peñón	Meridian Gold Corp., Canada		Pre-feasibility	Gold: 3,100-6,200 Kg/year	
Chim-borazo	Inmet Mining, Canada Agate Bay, Canada		Study	Copper Cathodes 50,000 ton/year	
Escondida	BHP Utah, Australia RTZ, England JECO, Japan IFCO., I.	470	Extension	Fine Copper (1996) 841,000 ton/year Oxides Plant (Fine Copper) 120,000 ton/year	1998
Yolanda	Kap Resources Ltd., Canada 10224 Yukon-Canada Corporación Interamericana de Inversiones-O.I.	90	Construction	Iodine: 330,000 ton/year Sodium and/or Potassium Nitrate 300,000 ton/year	1997
REGION III					
Manto Verde	Anglo-American Group South Africa	178	Operating	Copper cathodes 42,000 ton/year	1996

<i>Project</i>	<i>Investors</i>	<i>Estimated total investment (in million US\$)</i>	<i>Phase</i>	<i>Production</i>	<i>Start</i>
El Hueso Agua de la Falda	Homestake Mining Company of California, USA CODELCO, Chile	8	Construction	Gold: 1,200 kg/year	1997
Chimberos	Placer Dome, Canada TVX Gold, Canada	30	Study	Silver:	1998
Lobo/Marte	Minera Santa Rosa (Anglo, American), South Africa	350	Study	Gold: 9,000-11,000 kg/year	2000
Refugio	Bema Gold-Canada Amax Gold Refugio Inc., USA	130	Operating	Gold: 7,200 kg/year	1996
Candelaria	Phelps Dodge, USA Sumitom, Japan	337	Operating and Extension	Copper in Concentrates 137,000 ton/year/actual Additional Copper in Concentrates 40,000 ton/year	1998
Aldebarán/ Cerro Casale	Arizona Star Resources Canada Bema Gold Corp., Canada		Study	Gold 1,000-6,000 kg/year	
REGION IV					
Andacollo Cobre	Enami-Chile Tungsten Int. Inc.-Canada	84	Operating	Copper Cathodes 20.000 ton/year	1996
Los Pelambres	Nippon Mining and Metals-Japan Mitsubishi Corp-Japan Marubeni Corp.-Japan Mitsui and Co.-Japan Grupo Luksic-Chile	1.322	In study	Fine Copper in Concentrates 220.000 ton/year	1999

<i>Project</i>	<i>Investors</i>	<i>Estimated total investment (in million US\$)</i>	<i>Phase</i>	<i>Production</i>	<i>Start</i>
REGIONS V AND VI AND METROPOLITAN REGIONS					
Pullalli	Pegasus Gold Corp. USA Zotman Mining-USA	50	In study	Gold: 2.800 Kg/year	1998-99
Fundición Chagres	Exxon Minerals Int. Corp USA	209	Operating	Blister Copper 120.000 ton/year	1995
Los Bronces and Las Tórtolas	Exxon Minerals Int. Corp. USA	550	Operating Extension in study	Fine Copper (1996) 120.000 ton/year Fine (ext) 240.000 ton/year	2000
REGIONS VII-XII					
Fachnial/Laguna Verde	CDE Chilean Mining Corp. USA	68	Operating	Gold: 1.400 Kg/year Silver: 62.000 Kg/year	1996

ANNEX VI

ENVIRONMENTAL POLICY AND EMISSION REDUCTION PLANS IN THE MINING SECTOR

Below is a brief review of the environmental policy and management plans in the mining sector, as well as decontamination and pollution reduction plans at some of the major copper mines and smelters. For the latter, only incomplete information is available, and not all of it covers exactly the same ground (e.g., period covered; basis of calculation of emissions; types of emissions). In spite of these inconsistencies, it is possible to form an impression of the level of reductions.

1. Public Sector Operations

1.1 Environmental policy and management

Public sector operations defined explicit environmental policies only in 1990, and subsequently, modern environmental management practices have been adopted relatively quickly. This is of critical importance, because many of the installations use outdated technology—some are more than 50 years old.

CODELCO has established an Environmental Management Unit within the corporate structure; functions include development of policy and guidelines, coordination of the work of the corporate divisions, control of implementation of environmental goals and objectives and compliance with environmental regulations. This work is supported by environmental units in the Operational Divisions. The Corporate Plan for Decontamination of Smelters is the main environmental programme; it aims at complying with national regulations and achieving a 95 per cent capture of pollutants (higher than the national norm and equivalent to what is current practice in developed countries). To achieve this, *CODELCO* has developed original technology—the Teniente Process. This has been applied in all of its own smelting facilities, as well as in two national and three internationally owned smelters in Chile. In addition, the technology is being exported. Investments in decontamination have grown from 10.1 per cent of the total investment budget in 1990-1993, to 25 per cent in 1997-1999.

ENAMI: A Corporate Environmental Division has been established, and a programme—Environmental Management in the Smelter and Refinery of Ventanas: a Participatory Process in Action—has recently been launched to deal with conflicts with local communities. Overall, *ENAMI* has invested US\$ 60 million in the first part of the decade; investment in 1996 alone was US\$ 32.7 million, an increase of 76.8 per cent over the previous year.

1.2 Mitigation plans and measures

With the entering into force of new environmental legislation, most of the public sector companies either have already started implementing mitigation measures or are planning to do so. These PLANS are briefly described below:

Chuquicamata (CODELCO): Average production is 5,000 ton/day of copper. It has been declared a SO₂ saturated zone. Emissions in 1992 were 261,000 ton/year of sulphur and 1.1 ton/day of arsenic. Emission reductions for sulphur are planned to go from 252,000 ton/year in 1993, to 198,000 ton/year in 1995, to 162,000 ton/year in 1998. For particulate matter, the plans are to go from 9,700 ton/year in 1993, to 3,240 ton/year in 1995, to 3,240 ton/year in 1998. For arsenic, the plans are to go from 2,700 ton/year in 1993 to 1,870 ton/year in 1995. All emissions are planned to be within established norms by 1999. Changes in technology—amounting to a US\$ 600 million investment—have already taken

place; two Teniente converters and one Flash oven as well as four sulphuric acid plants which process 75 per cent of gases that are generated have been installed. Further improvements—amounting to a US\$ 150 million investment—will set in place another Teniente converter and Flash oven; future plans include reduction in the pyrites contained in the concentrate and expansion in capture of acid gases, to achieve a 75 per cent rate.

Caletones (CODELCO): Average production is 3,500 ton/day of copper. It has been declared a SO₂ and particulate matter saturated zone. Emissions in 1992 were 405,549 ton/year of sulphur and 0.3 ton/day of arsenic. Emission reductions for sulphur are planned to go from 375,000 ton/year in 1998, to 115,000 ton/year in 2001, and to be within established norms by 2003. For particulate matter, the plans are to go from 3,017 ton/year in 1998, to 1,987 ton/year in 2000, and to be within established norms by 2001. Teniente technology is in operation; there are plans to introduce two sulphuric acid plants, first reducing emissions by 37 per cent and a transition plan with a view of eventually complying with established norms. Investments in these measures are US\$ 150 million.

Potrerrillos (CODELCO): Average production is 1,500 ton/day of copper. It has been declared a SO₂ and particulate matter saturated zone. Emissions in 1992 were 161,769 ton/year of sulphur and 0.3 ton/day of arsenic. Emissions for sulphur are planned to stabilize around 170,000 ton/year in 1997-1998, and for particulate matter, the plans are to stabilize at 10,800 ton/year during the same period. Teniente technology is in operation; there are plans to install equipment to process waste gases, amounting to an investment of US\$200 million.

Ventanas (ENAMI): Average production is 380 ton/day of copper. It has been declared a SO₂ and particulate matter saturated zone, and produces 95 per cent of total SO₂ and 11 per cent of particulate matter in the area. Emissions in 1992 were 57,700 ton/year of sulphur and 0.3 ton/day of arsenic. Emission reductions for sulphur are planned to go from 62,000 ton/year in 1993, to 45,000 ton/year in 1998. For particulate matter, the plans are to go from 3,400 ton/year in 1993, to 2,000 ton/year in 1998. All emissions are planned to be within established norms by 1999. There are plans for installation of improved technology and construction of a sulphuric acid plant.

Paipote (ENAMI): Average production is 170 ton/day of copper. It has been declared a SO₂ saturated zone. Emissions in 1992 were 26,922 ton/year of sulphur. Emission reductions for sulphur are planned to go from 39,900 ton/year in 1995, to 30,000 ton/year in 1998, to 19,992 ton/year in 1999, and to be within established norms by 2000. For particulate matter, the plans are to go from 1,500 ton/year in 1995, to 1,000 ton/year in 1998, to 600 ton/year in 1999. For arsenic the plans are to go from 84 ton/year in 1995 to 42 ton/year in 1999. A project to modify the smelters and increase the capacity of the sulphuric acid plant is under way.

2. Private Sector Operations

The Chilean Association of Industrial Producers (SOFOFA) produced an environmental policy in 1989 and this is having a positive effect on the environmental performance of the private sector mining. Environmental management practices were introduced first by the larger companies, based on international standards. These are often more stringent than the requirements by Chilean law (Ministry of Mining, 1996). For example, Chagres—the only private sector smelter—has installed equipment that reduces SO₂ by 94 per cent, and is thus the only smelter in Chile that complies with air quality standards.

In addition to following the overall environmental policies of their Headquarters outside Chile, the companies have high level executives responsible for environmental management. Specific actions required by the companies include use of environmentally benign technology, application of EIA to operations, as well as monitoring, follow-up and audits. Provision of information to the public is based on a policy of transparency; a system of consultation with employees, the community and interested groups is also in place (CEPAL, 1997).

Medium and small companies generally do not apply environmental management practices, nor do they have modern installations allowing reduction of emissions.

ANNEX VII

ENVIRONMENTAL POLICY AND MANAGEMENT AT ESCONDIDA MINE

(Source: CEPAL, 1997 and interviews)

Environmental management is a priority issue at the Escondida Mine. In keeping with international trends in the mining sector, special structures and procedures have been established to deal with environmental issues. There is a well defined environmental policy and system of environmental management, supported by a specific Office for Natural Resources and Environment, attached to the Vice-presidency for Operations. A monitoring system to review the effects of operations is also in place.

1. Environmental Policy

The policy framework at Escondida—in line with that of the main shareholder, the Australian Broken Hill Proprietary Ltd. (BHP)—promotes the achievement of the highest standards of environmental protection in its operations, incorporating technological advances and scientific knowledge, as well as the interests of workers, the surrounding community and the natural environment. To facilitate this task, the mine is affiliated with environmental organizations such as the Industrial Association of Antofagasta, the National Oceanographic Committee and the Chilean Society for Ocean Sciences.

2. The Environmental Management System

Environmental management is approached in an integrated and rigorous manner; the goal of the system is to implement *best practices* according to international standards and is structured around identification of potential impacts; establishment of control standards; measurement of parameters; evaluation of results; and correction and mitigation. Overall environmental management procedures currently in place include establishment of baseline data, environmental impact studies of planned interventions, monitoring of the status of the environment and external environmental audits. The latter are carried out by the owner BHP and its British partner RTZ every three years and are designed to ensure implementation of *best practices*.

The environmental management system revolves around two main elements, namely the working environment and the natural environment. The former covers security measures, use of materials and management of pollutants according to national and international standards; there is an associated Total Health Plan designed to protect the workers and includes education and training programmes on various aspects of environmental management.

3. The Environmental Management Programme

The environmental management programme focuses on three main elements, namely:

Water quality: Water for mining operations is reused and recycled at various areas in the mine and shipping port of Coloso. A 100 km gravitational hydraulic system for the transport of mineral to the port ensures dust-free and energy efficient operations. This water is also recycled and used for industry, irrigation, cleaning of the plant and firefighting. Residues are disposed of at sea in such a manner as to have as little environmental impact as possible—since 1991 residues are well below required thresh-

olds. Water for human consumption is treated in four on-site plants and is then recycled for irrigation. All water is subject to strict quality control.

Air quality: The programme includes regular monitoring of total particulates and of concentrations of CO, NO and NO₂; at present, contamination levels are below those required by law. There is a network of eight monitoring stations in Coloso and norms have been met most of the time, except in 1992, when suspended dust particle requirements were exceeded and corrective measures put in place. A technological contribution—developed by BHP—for treating copper used in the production of cathodes uses ammonia-based leaching procedures at normal temperatures and pressures; this allows to avoid additional processes and consequent air pollution. The procedure is carried out at a specially built plant and the ammonia is recycled.

Management of residues: Solid mining residues are sorted and separated into reusable material; the non-usable residues are disposed of in a sanitary landfill; toxic residues are placed in sealed drums. Industrial residues, including non-ferrous metals, wood and plastics are disposed of at another designated site, while domestic residues are consigned to the municipal refuse facility.

4. Special Focus on Water Management

Water is a fundamental element in the production process as well as in the welfare of workers. Its management therefore is considered to be a matter of priority, and shall be described here in greater detail. At the start of mining operations in 1989-1990, studies were undertaken to examine the functioning of the local ecosystem, water regime and subterranean aquifer. The water used by the mine was discovered during explorations; being a new source, potential conflicts with established users in the area are avoided. Among the various stages and activities around which water management is articulated, the following can be mentioned:

Use and reuse of water: Efficiency in the use of water is stressed. Demand for fresh water has decreased significantly, from a historically high 1.1 cubic meters per ton of processed ore to 0,7, cm/ton today. This has been made possible by investments in improved processes and plant. Water for mining requirements is mostly recycled, and only one third comes from direct sources.

Recycling plants at Escondida and Coloso: A system of closed basins to treat used mine water and reduce water lost to evaporation is in place; high density polyethylene liners and tubing are used throughout the system to reduce possibility of leakage to the surrounding areas, subterranean aquifers and the marine environment.

Desalinizing plant: The system for desalinization uses sea water; intake is mixed, with direct intake from the sea as well as indirect intake from the return flux of the cooling system used in the ammoniacal leaching process mentioned above. It is very efficient as well as non-polluting.

Hydraulic transport system: Water used for transport of ores is put through a series of filtering systems, including decanting ponds that remove most particulate matter; a secondary system of automatic recycling through three sand filters is also used. Water that is not used or stored is disposed of at sea.

Drinking water and sanitation: Potable water is brought in from the city of Antofagasta, but effluents are treated *in situ* and reused in mining operations.

Water management and green areas: A system of green areas has been created using recycled water before final discharge; a holding pond and a drip system ensure irrigation. The plant species are adapted to arid and saline conditions; although currently introduced ornamental species are the norm, a programme for conservation of native cacti is under consideration.

REFERENCES

Background documents

1. Borregaard N. (Co-ord), H. Blanco, F. Wautiez, 1997. *Impactos Ambientales de la Liberalización Comercial del Sector Minero Chileno*. CIPMA, Santiago de Chile. (Main report 100 pp.; Annexes 37 pp.).
2. Volpi, G. 1997. *Managing Trade Policies for Environmental Sustainability—Towards a Framework for Assessing the Environmental Impact of Trade Liberalisation: The Case of the Chilean Mining Sector*, UNEP internal document, Geneva, (Main report 69 pp.; Annexes 11 pp.).

The following documents are consolidated references:

1. Agacino, R., J. Rojas y C. González. 1997. *Transnacionalización y Precarización del Empleo en la Minería Chilena*. PET, Santiago de Chile.
2. Anderson and Blackhurst (eds.) 1992. *The Greening of World Trade Issues*. London.
3. Arden-Clarke, C. 1991. *International Trade, GATT and the Environment*. WWF International, Position Paper, Gland.
4. Arden-Clarke, C. 1991. *The General Agreement on Tariffs and Trade, Environmental Protection and Sustainable Development*. WWF International, Discussion Paper, Gland.
5. Arteaga, J. and H. Durán. 1994. *Contaminación Atmosférica en Chile: Antecedentes y Políticas para su Control*. In CONAMA (Ed.) Perfil Ambiental de Chile, Santiago de Chile.
6. Astorga, T. 1994. *Tributación Minera en Chile, un Factor de Inversión*. Santiago de Chile. Banco Central de Chile. 1996. *Economic and Financial Report*. Santiago de Chile.
7. Barbier, E. 1994. 'The Environmental Effects of Trade in the Forestry Sector', in OECD *The Environmental Effects of Trade*, Paris.
8. Barret, E. B. 1993. 'Strategic Environmental Policy and International Competitiveness' in OECD *Environmental Policies and Industrial Competitiveness*, Paris.
9. Beckerman, W. 1995. 'Growth, the Environment and the Distribution of Incomes: Essays by a Skeptical Optimist'. *Economists of the Twentieth Century Series* by Edward Elgar.
10. Beghin, J., B. Bowland, D. Dessus, D. Roland-Holst, and D. van der Mensbrugge. 1966. *Growth, Trade, Pollution and Natural Resource Use in Chile: Evidence from an Economy Wide Model*. OECD Development Centre Paper, Paris.
11. Beghin, J., D. Roland-Holst and D. van der Mensbrugge. 1966. *A Survey of the Trade, and Environmental Nexus: Global Dimensions*. OECD Development Centre Paper, Paris.
12. Birdsall, N. and D. Wheeler. 1992. 'Trade Policy and Industrial Pollution in Latin America: Where are the Pollution Havens?' in Low, P. (Ed.) *International Trade and the Environment*. World Bank Discussion Paper 159, Washington.

13. Cabrera, N. 1994. Estado de las Aguas Continentales y Marinas de Chile, in CONAMA (Ed.) Perfil Ambiental de Chile, Santiago de Chile.
14. Canadian Government. 1992. *North American Free Trade Agreement: Canadian Environmental Review*, Ottawa.
15. Canadian Government 1992. *Uruguay Round of Multilateral Trade Negotiations: Canadian Environmental Review*. Department of Foreign Affairs and International Trade, Ottawa.
16. CEPAL 1989. *Impacto Tecnológico y Productivo de la Minería del Cobre en la Industria Chilena 1955-1988*. Santiago de Chile,
17. CEPAL 1994. *El Dominio y Soberanía de los Recursos Mineros y los Regímenes Actuales de Concesiones en los Países de America Latina y El Caribe y sus Tendencias*. Santiago de Chile.
18. CEPAL 1995. *Competitividad e Incorporación del Progreso Técnico en la Minería de Oro y Cobre*. Santiago de Chile.
19. CEPAL 1996. *La Minería de America Latina y El Caribe en el Contexto Mundial*. Santiago de Chile.
20. CEPAL 1996. *Reformas Mineras y Políticas para Promover la Inversión en America Latina y El Caribe*. Santiago de Chile.
21. CEPAL 1997. *La Variable Ambiental en la Inversión Minera Transnacional: el Caso del Cobre en Chile*. Santiago de Chile.
22. Charnovits, S. 1995. 'Improving Environmental and Trade Governance' in *International Environmental Affairs*, vol . 7, No. 1.
23. Comisión Chilena del Cobre. 1996. *Diagnóstico Regional de la Minería*. Documento Interno, Santiago de Chile.
24. Comisión Chilena del Cobre 1996. *Estadísticas del Cobre y Otros Minerales*. Colección Anuarios, Santiago de Chile.
25. Comisión Chilena del Cobre. 1996. *Inversión Extranjera en la Minería Chilena 1996*. Colección Anuarios, Santiago de Chile.
26. Comisión Chilena del Cobre 1996. *The Copper Boom in the Chilean Economy: What Should We Expect?* ILADES-Georgetown University and Gerens Ltda.
27. Comisión Chilena del Cobre. 1995. *Estadísticas del Cobre y otros Minerales*. Colección Anuarios, Santiago de Chile.
28. Comisión Chilena del Cobre. 1995. *Inversión Extranjera en la Minería Chilena 1995*. Colección Anuarios, Santiago de Chile.
29. Comisión Chilena del Cobre 1990. *El Impacto Ambiental de la Minería en Chile*. Documento Interno. Santiago de Chile.
30. Commission for Environmental Co-operation (CEC). 1996. *Building a Framework for Assessing NAFTA Environmental Effects*. Report of a Workshop held at La Jolla, California.
31. Commission for Environmental Co-operation (CEC). 1997. *A Shared Vision: Towards Sustainability in North America*. Montreal.
32. CONAMA. 1992. *Informe Nacional a la Conferencia de las Naciones Unidas sobre Medio Ambiente y Desarrollo*, Santiago de Chile.
33. CONAMA. 1994. *Perfil Ambiental de Chile*, Santiago de Chile.

34. Council of the EC. 1996. Council decision on the Exchange of Letters between the European Community and Chile concerning the provisional application of certain provisions of the Framework Co-operation Agreement (. . .), in *OJEC* No. L209/1 of 19.08.96.
35. Daly, H. E. 1993. 'The Perils of Free Trade' in *Scientific American*. November.
36. Daly, H. E. and R. Goodland. 1994. 'An Ecological-Economic Assessment of Deregulation of International Commerce and GATT' in *Ecological Economics*, vol. 9, No. 1.
37. De Mestral, A. L. C. 1996. *Dispute Avoidance: Weighing the Values of Trade and the Environment under the NAFTA and the NAAEC*. Environment and Trade Series No. 1 Commission for Environmental Co-operation, Montreal.
38. Dean, J. M. 1992. 'Trade and the Environment: A Survey of the Literature', in P. Low, (Ed). *International Trade and the Environment*. World Bank Discussion Paper 159, Washington.
39. Dreher, A. 1990. *Inversión en la Minería: Viga Maestra del Desarrollo Regional*, en Documentos de Seminario; *Ciclo Acción Ambiental: Obstáculo o Impulso al Desarrollo?*; Seminario Sector Minero, 11-12 Mayo, CIPMA, Santiago de Chile.
40. Ecología and Desarrollo 1995. *Medio Ambiente en Chile: Situación y Programas*. Estudio elaborado para el Ministerio de Hacienda/CONAMA. Santiago de Chile.
41. Economist Intelligence Unit (the) 1996. *Chile Country Profile*. London.
42. EC Commission 1990. *1992: The Environmental Dimension*. Task Force on Environment and Internal Markets. Economica, Verlag, Bonn.
43. EC Commission 1996. *Communication from the Commission to the Council and the European Parliament on Trade and the Environment*. COM (96) 54 final, Brussels.
44. EC Commission 1997. *European Commission Wants to Appeal Final WTO Panel Ruling Against EU Ban on Imports of Hormone-Treated Meat*. Press Release, Brussels.
45. Economic Commission for Europe. 1992. *Application of Environmental Impact Assessment Principles to Policies, Plans and Programmes*. Environmental series No. 5, ECE/ENVWA/27. New York.
46. Eggert, R. 1994. 'Mining and the Environment: An Introduction and Overview' in R. Eggert, *Mining and the Environment*. Resources for the Future, Washington.
47. Ekins, P., C. Folke, and R. Costanza 1994. 'Trade, Environment and Development: The Issues in Perspective' in *Ecological Economics Vol. 9*.
48. Environmental Resources Management 1993. *Overview of Environmental Issues and Priorities in Chile*. Overseas Development Administration, London.
49. Esty, D. 1995. *NAFTA Effects a Survey of Recent Attempts to Model the Environmental Effects of Trade: An Overview and Selected Sources*. Environment and Trade Series. Commission for Environmental Cooperation, Montreal.
50. European Parliament (EP) 1996. *Report on the Communication from the Commission to the Council and the European Parliament on Trade and the Environment*. COM (96) 0054-C4-0158/96, Strasbourg.
51. Ewing, K. P. and R. G. Tarasofsky. 1997. *The Trade and Environment Agenda: Survey of Major Issues and Proposals—From Marrakesh to Singapore*. Environmental Policy and Law Paper No. 33. IUCN, Gland.

52. French-Davis, R. and R. Saez. 1995. *Comercio y Desarrollo Industrial en Chile* in *Colección de Estudios CIEPLAN* No. 41.
53. Fiedor, B., S. Czaja, A. Grazyk and J. Rymarczyk. 1994. *Linkages Between Environment and Development: A Case Study of Poland*, UNCTAD, Geneva.
54. Figueroa, B. et al. 1996. *Chile, Trade and the Environment*. UNCTAD Country Study, Geneva.
55. Figueroa, E., G. Donoso, G. Lagos, R. Alvarez and J. Muñoz. 1996. *Sustentabilidad Ambiental del Sector Exportador Chileno* in Sunkel, O. (Ed.) *Sustentabilidad del Crecimiento Económico Chileno. Programa del Desarrollo Sustentable*, Centro de Análisis de Políticas Públicas, Universidad de Chile, Santiago de Chile.
56. French, H. 1993. *Costly Trade-Offs: Reconciling Trade and the Environment*. Worldwatch Paper 113, Washington.
57. Gana, J. 1992. 'Determinants of Innovation in Copper Mining' in *Resources Policy*, vol. 21.
58. GATT, 1994. *The Results of the Uruguay Round of Negotiations*. GATT Secretariat, Geneva.
59. Gaviria, D., R. Gomez, L. Ho, and A. Soto. 1994. *Reconciliation of Trade and Environment Policies: The Case Study of Colombia*. UNCTAD, Geneva.
60. Gomez-Lobo, A. 1992. 'Las Consecuencias Ambientales de la Apertura Comercial en Chile' in *Colección de Estudios CIEPLAN* No. 35.
61. Geisse, G. *Problemas y Posibilidades de Transformación Productiva con Conservación Ambiental en Cuatro Sectores de Actividad de la Economía Chilena*.
62. Gonzalez, S. 1994. *Estado de la Contaminación de los Suelos en Chile*, in CONAMA (Ed.). *Perfil Ambiental de Chile*, CONAMA, Santiago de Chile.
63. Grossman, G. M. and A. Kruger. 1991. *Environmental Impacts of the North American Free Trade Agreement*. National Bureau of Economic Research, Working paper No. 3914, Cambridge, Mass.
64. Grossman, G. M. and A. Kruger. 1995. 'Economic Growth and the Environment' in *Quarterly Journal of Economics*, vol. 110, No. 2.
65. Hardin, G. L. 1986. 'The Tragedy of the Commons' in *Science* vol. 162, pp. 1243-48. Reprinted in Dorfman, R. and E. Dorfman (Eds.) 1993. *Economics and the Environment: Selected Readings*. Norton & Co., New York and London.
66. Harwell, C. C., R. Hanes, M. Acevedo, M. A. Harwell and A. Serbin. 1994. *Free Trade and the Environment: A Prospective Analysis and Case Study of Venezuela*. University of Miami.
67. Hayek, E., P. Gross and G. Espinoza. 1990. *Problemas Ambientales de Chile*. Study done for and published by CONAMA, Santiago de Chile.
68. Ibacache, A. M. 1995. *Diagnóstico de la Situación Actual del Sector Minero: Sector Público*. Workshop on Desafíos de Medio Ambiente en Minería. Centro de Estudios del Cobre y la Minería (CESCO), Santiago de Chile.
69. IBRD. 1992. *Development and the Environment: World Development Report 1992*. Oxford University Press, New York.
70. InduAmbiente. 1997. Special issue on mining. *InduAmbiente*, Year 5, No. 27, July-August 1997.

71. Intal, P., E. Medalla, M. de los Angeles, D. Israel, V. Pineda, P. Quintos and E. Tan. 1994. *Trade and Environment Linkages: The Case Study of Philippines*. UNCTAD, Geneva.
71. International Institute for Sustainable Development (IISD) 1992. *Trade and Sustainable Development: A Survey of the Issues and a New Research Agenda*. Winnipeg.
72. Johnston, N. 1996. *International Trade and Environmental Quality* in Swanson, T. *The Economics of Environmental Degradation: Tragedy for the Commons?* United Nations Environment Programme, Edward Elgar Publishing, Cheltenham.
73. Kirton, J. and J. Soloway. 1996. *Assessing NAFTA's Environmental Effects: Dimensions of a Framework and the NAFTA Regime*. NAFTA Effects Series Working Paper No. 1, Commission for Environmental Cooperation, Montreal.
74. Kuik, O. J., H. Verbruggen and S. Hoefnagel. 1996. *The Consequences of the Uruguay Round Agreements for Dutch National and International Policies*. Institute of Environmental Studies, Free University of Amsterdam.
75. Lagos, G. 1992. *Mining and the Environment in Chile*. Paper for the Colorado School of Mines.
76. Lagos, G. 1993. 'Política y Gestión Ambiental' in Díaz et al. (Ed.). *El Medio Ambiente en la Minería*. Instituto de Estudios Internacionales, Universidad de Chile y COCHILCO, Santiago de Chile.
77. Lagos, G. 1996. *Requerimientos y Desafíos Ambientales para la Minería Chilena*. Presentation to the V Encuentro Científico, organized by CIPMA in Temuco, Chile. CIPMA, Santiago de Chile.
78. Lagos, G. 1997. 'Developing National Mining Policies in Chile: 1974-96' in *Resources Policy*, vol. 23, No. ½, pp. 51-69.
79. Lagos, G. and P. Velasco. 1994. *Environmental Policies and Practices of Selected Mining Companies in Chile: A Case Study*. Unpublished report.
80. Leal, J. 1997. *Los Sistemas de Evaluación de Impacto Ambiental en los Países del MERCOSUR*. Internal report, CIPMA, Santiago de Chile.
81. Lu, R., Y. Xia, J. Li, J. Zhang and Y. Lu. 1994. *Trade and Environment Linkages: The Case Study of China*. UNCTAD, Geneva.
82. Markandaya, A. 1995. *Reconciliation of Environmental and Trade Policies: Synthesis of Country Case Studies*. Paper prepared for UNCTAD, Geneva.
83. Masera, O. and V. Maclaren. 1996. *NAFTA's Environmental Effects: Dimensions and Indicators of Environmental Quality*. NAFTA Effects Series Working paper No. 5, Commission for Environmental Cooperation, Montreal.
84. Meller, P. 1992. Review of the Chilean trade liberalization and export expansion process (1974-1990) in *The Bangladesh Development Studies*, vol. 20, Nos. 2 and 3.
85. Méndez, J. C. 1993. *Análisis de las Fuentes de Financiamiento de CODELCO*. Centro de Estudios Públicos (CEP), Santiago de Chile.
86. *Minería Chilena*, several issues.
87. Ministerio de Minería. 1994. *Impactos del NAFTA y el MERCOSUR en las Exportaciones y Empleo del Sector Minero*, Santiago de Chile.

88. Ministerio Secretaría General de la Presidencia. 1997. Reglamento del SEIA. *Diario Oficial de la República de Chile, jueves 3 de abril de 1997.*
89. Ministry of Mines, Chile. 1996. *Environmental Management in the Mining Sector.* Draft document produced in collaboration with the Canadian Department of Foreign Affairs and International Trade.
90. O'Brian, J. 1994. *Undoing the Myth: Chile's Debt to Copper Mining.* International Council on Metals and the Environment, Ottawa.
91. OECD. 1993. *Procedural Guidelines on Trade and Environment.* Paris.
92. OECD. 1994. *The Environmental Effects of Trade.* Paris.
93. OECD. 1995. *Trade and Environment.* Report to the OECD Council at Ministerial Level. Paris.
94. OECD. 1996. *Implementation of the OECD Procedural Guidelines on Trade and Environment.* Report of the OECD Secretariat, Paris.
95. OECD. 1996. *Reconciling Trade, Environment and Development Policies. The Role of Development Co-operation,* Paris.
96. Oosterhuis, F. and O. Kuik. 1997. *Environmental Impacts of Trade Liberalization Between the EU and the New Market Economies in Europe.* Institute of Environmental studies (IVM), Amsterdam. Draft paper commissioned by the European Environmental Agency.
97. Pagani, J., C. Huepe, A. M. Ibacache and J. Solari. 1992. *Gestión Ambiental en el Sector Minero.* Documento de la Unidad de Medio Ambiente del Ministerio de Minería, Santiago de Chile.
98. Pagani, J., C. Huepe, A. M. Ibacache y J. Solari. 1994. *Efectos Ambientales Derivados de la Actividad Minera en Chile,* in CONAMA 1994. Perfil Ambiental de Chile, CONAMA, Santiago de Chile.
99. Panayotou, T. and K. Hupj. 1996. *Environmental Impacts of Structural Adjustment Programmes: Synthesis and Recommendations.* Environmental Economics Series Paper No. 21, United Nations Environment Programme.
100. Pearce, D. W. and J. J. Warford. 1993. *World Without End: Economics, Environment and Sustainable Development.* Oxford University Press, Oxford.
101. Pearson, C. 1993. "Trade and Environment: the United States Experience", in UNCTAD, *Trade and Environment: The International Debate.* Editorial Torino, Caracas.
102. Peña, H. 1994. *Efectos Ambientales Derivados del Uso de Recursos Hídricos en Chile* in CONAMA 1994. Perfil Ambiental de Chile, CONAMA, Santiago de Chile.
103. Quiroga, R. 1996. *Globalización e Insustentabilidad,* IEP, Santiago de Chile.
104. Quiroga, R. and S. Van Hauwermeiren. 1996. *Globalización e Insustentabilidad: Una Mirada Desde la Economía Ecológica.* Instituto de Ecología Política, Programa Economía Ecológica, Santiago de Chile.
105. Repetto, R. 1994. *Trade and Sustainable Development.* Environment and Trade Series No.1. UNEP, Geneva.
106. Rosenberg, R. 1997. Personal communication at the WTO-NGO Symposium on Trade and Environment (21 May 1997) Geneva.

107. Runge, C. F. 1994. *Freer Trade, Protected Environment: Balancing Trade Liberalization and Environmental Interests*. Council of Foreign Relations Press, New York.
108. Runge, C.F., E. Cap, P. Faeth, P. McGinnis, D. Papageorgiou, J. Tobey and R. Housman. 1997. *Environmentally Sustainable Trade Expansion in the Latin American Region: An Analysis and Empirical Assessment*. World Resources Institute, Washington.
109. Runnals, D. 1992. *Trade and Sustainable Development: A Survey of the Issues and a New Research Agenda*. International Institute for Environment and Development, Winnipeg.
110. Sánchez, J. M. y S. M. Enríquez. 1997. *Impacto Ambiental de la Pequeña y Mediana Minería en Chile*. Report for the Division of Industry and Mining, World Bank. Departamento de Economía, Universidad de Chile, Santiago de Chile.
111. Schurman, R. A.. 1996. 'Snails, Southern Hake and Sustainability: Neoliberalism and Natural Resource Exports in Chile', in *World Development*, vol. 24, No. 11.
112. Selden, T. M. and D. Song. 1994. 'Environmental Quality and Development: Is there a Kuznets Curve for Air Pollution?', in *Journal of Environmental Economics and Environmental Management*, vol. 27, No. 2.
113. Shafik, N. And S. Bandyopadhyay. 1992. *Economic Growth and Environmental Quality: Time Series and Cross-Country Evidence*. Background paper for the World Development Report 1992. World Bank, Washington.
114. SONAMI. 1996. *Balance Social de la Minería Privada 1966*. Santiago de Chile.
115. Spalding, M. and M. Stern. 1995. *Potential NAFTA Environmental Effects: Claims and Arguments, 1991-1994*. Environment and Trade Series No. 2. Commission for Environmental Cooperation, Montreal.
116. Stern, D., M. S. Common and E.B. Barbier. 1996. 'Economic Growth and Environmental Degradation: The Environmental Kuznets Curve and Sustainable Development'. *World Development*, vol. 24. No. 7.
117. Swanson, T. 1996. *The Economics of Environmental Degradation: Tragedy for the Commons?* United Nations Environment Programme, Edward Elgar Publishing, Cheltenham.
118. Therivel, R. and M. Partidario. 1996. *Strategic Environmental Assessment in Practice*. Earthscan, London.
119. Toro, R. J. 1993. *La Reforma del Sistema Tributario Chileno*. Servicio de Impuestos Inter-nos, Santiago de Chile.
120. USAID/Chile. 1989. *Environmental and Natural Resources Strategy in Chile*.
121. US Government. 1991. *Review of US-Mexico Environmental Issues*, Washington.
122. US Government. 1993. *The NAFTA: Report on Environmental Issues*, Washington.
123. US Government. 1994. *The GATT Uruguay Round Agreements: Report on Environmental Issues*, Washington.
124. US Government. 1996. *Environmental Review of Trade Agreements at the National Level*. USTR, Washington.
125. UNCTAD. 1993. *Reconciliation of Environmental and Trade Policies: Description of the Programme of Work*. Geneva.
126. UNCTAD. 1993. *Trade and Environment. The International Debate*. Editorial Torino, Caracas.

127. UNCTAD. 1995. *Trade, Environment and Development: Lessons from Empirical Studies*. Synthesis reports. UNCTAD Secretariat, Geneva.
128. UNEP. 1995. *Report of the Ad Hoc Experts Workshop on Environmental Assessment of Trade Policy*. Environment and Trade Unit, UNEP, Geneva.
129. UNEP/EATR 1994. *An Overview of Environmental Indicators: State of the Art and Perspectives*. Environmental Assessment Sub-Programme, UNEP, Nairobi.
130. UNEP/IEPAC. 1991. *Environmental Aspects of Selected Non-Ferrous Metals Ore Mining. A Technical Guide*. IEO/UNEP, Paris.
131. UNEP/IEPAC. 1996. *Studies Illustrating Environmental Practices in Mining and Metallurgical Processes*. IEO/UNEP, Paris.
132. Vaughan, S., M. Lehtonen and K. Bidwell. 1995. *Environmental Review and Trade Liberalisation*. Discussion paper prepared by the Environment and Trade Unit, UNEP, Geneva.
133. Vera, M. 1961. *La Política Económica del Cobre en Chile*. Ediciones de la Universidad de Chile, Santiago de Chile.
134. Von Moltke, K. 1996. *The World Trade Organization and Sustainable Development: An Independent Assessment*. International Institute for Sustainable Development, Winnipeg.
135. Wolff, H., I. Weidig, M. Eland, S. Schörer and G. Schmid. 1994. *Conséquences Ecologiques des Accords GATT pour la Suisse*. Communiqué de presse. Prepared by PROGNOS, Bern.
136. World Bank. 1994. *Chile Managing Environmental Problems: Economic Analysis of Selected Issues*. Environmental and Urban Development Division, Latin American and Caribbean Region, Washington.
137. World Trade Organization. 1995. *Environmental Benefits of Removing Trade Restrictions and Distortions*. Report to the Committee on Trade and Environment. WTO Secretariat, Geneva.

LIST OF CONTRIBUTORS

The present report is the result of work conducted by a number of specialists on behalf of the United Nations Environment Programme.

CIPMA (Centro de Investigación y Planificación del Medio Ambiente) in Santiago de Chile was commissioned to carry out the case study of the mining sector in Chile. The resulting report, *Impactos Ambientales de la Liberalización Comercial del Sector Minero Chileno*, was prepared by staff of the Centre Nicola Borregaard, Hernán Blanco and Françoise Wautiez.

Nicola Borregaard was responsible for the coordination of the case study. She is currently Executive Director of CIPMA, where she has promoted research on trade and environment and on international influences on national production and has written numerous reports. She has a Ph. D. in Land Economy, Cambridge University, an M. A. in Economics, SUNY, Albany, New York, and specializations in environmental economics and environmental auditing.

Giulio Volpi carried out research on conceptual and methodological aspects. He is currently at ECOTEC Research and Consulting and is interested in globalization and trade-environment links. He has a degree in Political Science (Honours) focused on European Environmental Law, University of Pisa and an M. Sc. in Environmental Management, Erasmus University/Imperial College.

The result of his work is contained in the report *Managing Trade Policies for Environmental Sustainability—Towards a Framework for Assessing the Environmental Impact of Trade Liberalization: The Case of the Chilean Mining Sector*.

Hernán Blanco is currently Coordinator of the Environmental Management and Evaluation Unit, Centro EULA, Universidad de Concepción, and also works as an associate researcher with CIPMA. He specializes in environmental planning and impact assessment. He has a degree in Civil Engineering, focused on Hydraulics and Environment, Universidad Católica de Chile, and an M. Phil. in Environment and Development, Cambridge University.

Françoise Wautiez is currently an external researcher with CIPMA. She has held a series of advisory and consulting positions at the national level, and focuses on economics and environment, in particular globalization, economic evaluation of environmental impacts, assessment of environmental impacts of economic liberalization and local environmental management. She has a degree in Economics from the Universidad Bolivariana.

Andrea Matte-Baker synthesized the background material and contributed to the policy analysis. She specializes in environmental policy and strategy and integration of environment and development in decision-making. She has a Doctorate in Architecture, focused on urban and regional planning, from the University of Rome.