GENERAL EQUILIBRIUM ANALYSIS OF CROSS EFFECTS IN SOCIAL AND ENVIRONMENTAL POLICIES: CASE STUDY OF CHILE

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ABSTRACT

The analysis of the linkages between development policies and social and environmental variables is a neglected area within the huge body of literature on development. This paper focuses on the key interrelations among the economic, social and environmental elements of the sustainable development triangle. A through review is undertaken of both social and environmental policies in Chile, underlining important economic growth and reforms undertaken. Using the static CGE model ECOGEM-Chile, the economy wide impacts of several environmental, social, and combined policies are simulated for the Chilean economy. Six different policies are simulated - three environmental policies that impose different taxes on PM10, SO2 and NO2 emissions, respectively; the same tax on PM10 with increased unemployment; one social policy that increases government transfers to households; and a mixed social-environmental policy package where the environmental tax on PM10 and the social transfer policy are simulated simultaneously. The results show that environmental tax policies may have negative social effects, using real disposable income by quintiles as proxy. The impacts depend on the use of the new revenues and the status of employment. Taxing PM10 emission yields better environmental results than taxing SO2 and NO2. Social policies do not show negative environmental impacts. Combined environmental and social policies improve results. The results show that the ECOGEM-Chile model is very useful for analyzing systematically and holistically, different economy wide policies and their impact on the Chilean economy. Winners and losers may be identified, as well as the potential magnitude of gains and losses.

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1. INTRODUCTION

In the 21st century, the concept of sustainable development is receiving increasing attention from world decision makers, in their search for new solutions to many critical problems including traditional development issues (such as economic stagnation, persistent poverty, hunger, malnutrition, and illness), as well as newer challenges (like, worsening environmental degradation and accelerating globalisation). Governments have accepted the responsibility for promoting the sustainability of development -- in response to the Agenda 21 program adopted unanimously at the 1992 United Nations Conference on Environment and Development (*UNCED*) in Rio 1992, and followed up at the 2002 World Summit on Sustainable Development (WSSD) in Johannesburg.

While no universally acceptable practical definition of sustainable development exists, the concept has evolved to encompass three major points of view - economic, social and environmental (*Munasinghe 1992*). For our purposes, sustainable development may be defined as a process for improving the range of opportunities that will enable individual human beings and communities to meet their needs, as well as to achieve their aspirations and full potential, over a sustained period of time, while maintaining the resilience of economic, social and environmental systems (*Munasinghe 1994*). This wider perspective on human well-being has encouraged researchers to look beyond traditional development goals like maximizing economic output, and pay more attention to environmental and social effects.

In this paper, we analyze the interrelation among environmental and social policies and their cross effects as well as the impacts on the key macroeconomic and sectoral variables, within a general equilibrium macroeconomic modeling framework applied to Chile. Thus, our work is the natural extension of a major trend in the literature, which has sought to examine countrywide or economywide policies (both macroeconomic and sectoral) and their powerful and pervasive impacts on environmental and social issues (see for example, *Munasinghe and Cruz 1994, Reed 1996, Munasinghe 2002*).

The paper is organised as follows. In the remainder of this 'Introduction', we summarise the computable general equilibrium (CGE) modelling framework that is used, and then review the relevant literature. Section 2 describes the main economic, social and environmental issues and policies in Chile. The ECOGEM-Chile model is applied to explore alternative environmental and social policies, and simulation results are discussed in Section 3. Finally, Section 4 summarises the main conclusions.

1.1 Computable General Equilibrium (CGE) Approach

A general equilibrium approach will generally capture complex inter-linkages among economic, environmental and social variables, better than partial equilibrium methods. It is often difficult to integrate these three major domains (and associated systems). The economic domain is geared mainly towards improving human welfare, primarily through increases in the consumption of goods and services. The environmental domain focuses on protection of the integrity and resilience of environmental systems. The social domain emphasizes the enrichment of human relationships and achievement of individual and group aspirations, including equity.

Since the precise definition of sustainable development remains an elusive (and perhaps unreachable) goal, it is more promising to pursue a less ambitious strategy that merely seeks to '***make development more sustainable'*** (*Munasinghe 1994*). Thus, our study focuses on beneficial (or adverse) changes in selected economic, environmental and social variables. Such an incremental (or gradient-based) method is more practical, because they help to identify and eliminate many unsustainable activities – often avoiding sudden catastrophic ('cliff edge') outcomes. The practical goal is an approach that will (*inter alia*) permit continuing improvements in the present quality of life at a lower intensity of resource use and reduced environmental degradation, thereby leaving behind for future generations an undiminished stock of productive assets (i.e., manufactured, natural and social capital) that will enhance opportunities for improving their quality of life.

Macroeconomic policies and strategies have widespread effects – typically, they range from exchange rate, interest rate, and wage policies, to trade liberalization, privatization, and similar programs. They are usually coupled with various sectoral measures, including pricing in key sectors like energy or agriculture, as well as broad sectorwide taxation or subsidy programs. Such economywide policies are often packaged within programs of structural adjustment, stabilization, and sectoral reform, aimed at promoting economic stability, efficiency and growth, and ultimately improving human welfare. Even though their primary objectives might be economic, countrywide policies have pervasive (and sometimes unforeseen) environmental and social consequences.

Thus, the complexity of the direct and indirect interrelations among economic, environmental and social variables calls for models that capture these complex linkages, and allow us to generate policy options that make development more sustainable. At the same time, these models must take into account market mechanisms and behavior of economic agents, which determine the effectiveness of public policies and achievement of desirable structural changes in the economy.

In this context, computable general equilibrium (CGE) models represent the economy of a country in a more realistic way by incorporating market mechanisms in the allocation of resources. Also, they have proved to be useful in defining the main relationships in the economy, and in evaluating quantitatively *ex-ante* the effects of different economic, social or environmental policies, while capturing indirect side effects which in many cases are not evident on an intuitive basis.

Figure 1.1 presents schematically the relationships that can be modeled by means of a CGE, based on the circular flow of the economy. It includes the main agents (firms, households, and government), flows of goods and services, payments to factors, international trade and relationships with the environment. Each agent is modeled according to certain behavior assumptions; in particular it is common to assume optimizing producers and consumers. Additionally, each market is modeled according to the specific reality of the economy, for instance as a competitive or non-competitive market, or in the case of the labor market, with or without full employment. These models reach equilibria according to Walras law, that is to say, by equating demand and supply at all markets, thus determining prices and quantities. A fundamental characteristic of the productive sector in these models is that, in the same way as input-output models, incorporate the demands for intermediate inputs, not just capital and labor. However, they differ from the input-output models by allowing the substitution among production inputs. This characteristic furnishes equilibria, which take into account the transmission of the effects through all the relevant markets. Additionally the government role is modeled applying taxes, subsidies and transfers.

Finally, it must be noted that the CGE model has integrated the analysis of short-term and long-term perspectives into the generation of development strategies and growth paths[1], with the short-term perspective focused on contingent situations and stabilization policies[2]. All this without loosing sight of the relevance of sectoral aspects related to technological or investment processes[3].

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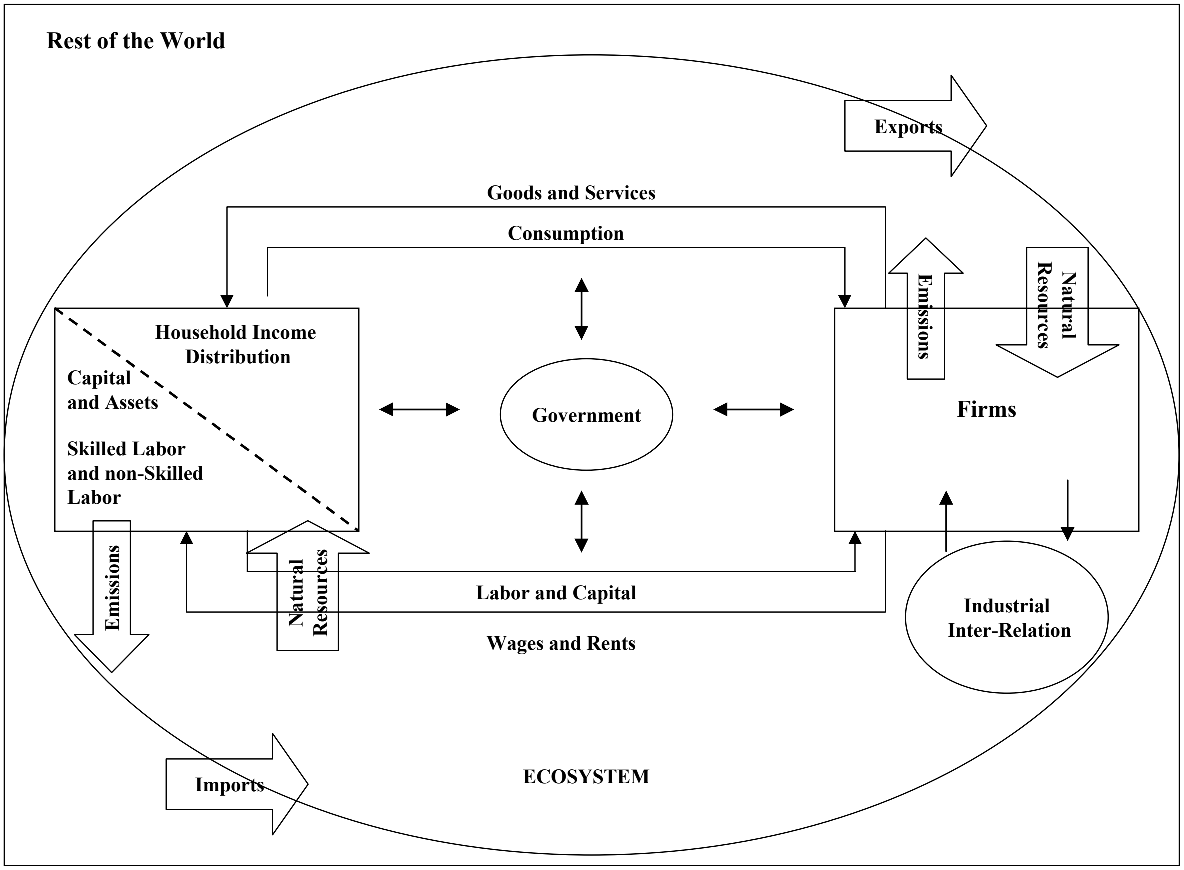
[1] Approach favored by Ministries of Planning and Economy, which makes use of input-output models, national accounts (especially social accounting matrices) and the real variables.

[2] More akin with monetary models and balances of nominal flows, used by Central Banks or Ministries of Economy and Treasury.

[3] Subject of study of sectoral or line ministries.

Figure 1.1 Economy circular flow



1.2 Relevant Applications of CGE Models

Worldwide Applications

CGE models have become a standard method for the analysis of a wide variety of traditional economic policies: structural adjustment, trade, taxation, foreign exchange, etc. (see the survey by *Gunning and Keyser 1993*). More recently, other elements of sustainable development, including social, environmental, poverty and equity issues have been investigated, using general equilibrium methods (*Conrad 1999*).

After the first use of a CGE model in Norway (*Johansen 1960*), the first set of applications focused on problems of optimal taxation and trade policies in the developed countries. Almost two decades later, applications to developing countries emerged (*Adelman and Robinson 1978* for Korea, and *Taylor et al. 1980* for Brazil). Throughout the 1980s, applications in developing countries evolved from the issues of poverty, income distribution and development strategies, through structural adjustment and stabilization policies to solve the debt crisis, to trade problems and strategies. In the nineties, CGE models were used to analyse poverty and income distribution issues, as well as environmental problems (*Devarajan 1997, Adkins and Garbaccio 1999*).

Models for developing countries have become more practical and realistic, by moving away from the strict neoclassical framework of original general equilibrium approach. Typical adaptations include departures from the Walrasian orthodoxy to account for structural rigidities like fixed wages, absence of mobility factor (*Taylor 1990*), as well as permitting imperfect competition and increasing returns to scale in trade models.

Linkages with the Environment

Empirically based research carried out at the World Bank in the late 1980s and early 1990s, including the application of CGE models to environmental issues, highlighted several conclusions that are relevant for this paper (*Munasinghe and Cruz 1994*). One main outcome of this work was that it is difficult to generalize about the environmental and social impacts of economywide policies, since the linkages tend to be extremely complex and country specific. However, some general conclusions do emerge.

On the positive side, liberalising reforms such as the removal of resource price distortions, promotion of market incentives, and relaxation of trade and other constraints often will contribute to both economic and sustainability gains (i.e., win-win outcomes). For example, policies that improve the efficiency of industrial, or energy related activities, could reduce economic waste, increase the efficiency of natural resource use and limit environmental pollution. Similarly, improving land tenure rights and access to financial and social services not only yields economic gains but also promotes environmentally sustainable land management and helps the poor.

In the same vein, there is evidence to show that shorter-run policy measures aimed at restoring macroeconomic stability will generally yield economic, social and environmental benefits, since instability undermines sustainable resource use and especially penalizes the poor. For example, price, wage and employment stability encourage a longer-term view on the part of firms and households alike. Lower inflation rates not only lead to clearer pricing signals and better investment decisions by economic agents, but also protect fixed income earners.

On the other hand, economywide structural reforms have had adverse environmental and social side effects. Such negative impacts are invariably unintended and occur when some broad policy changes are undertaken while other hidden or neglected policy, market or institutional imperfections persist. The remedy does not generally require reversal of the original reforms, but rather the implementation of additional complementary measures (both economic and non-economic) that remove such policy, market and institutional difficulties. These complementary measures are not only socially and environmentally beneficial in their own right, but also help to broaden the effectiveness of economywide reforms (see below).

Typical examples of potential environmental damage caused by ***policy distortions*** include export promotion measures that increase the profitability of natural resource exports, and encourage excessive extraction or harvesting of this resource if it were underpriced or subsidized (for example, low stumpage fees for timber). Similarly, trade liberalization could lead to the expansion of wasteful energy-intensive activities in a country where subsidised energy prices persisted.

Meanwhile, ***market failures*** such as external environmental effects of economic expansion (such as air or water pollution), induced by successful adjustment, may be cause excessive environmental damage, if these externalities are not adequately reflected in market prices that influence such activities.

Finally, unaddressed ***institutional constraints*** like the poor accountability of state-owned enterprises (which would allow them to ignore efficient price signals), weak financial intermediation, or inadequately defined property rights, tend to undermine incentives for sustainable resource management and worsen equity.

The shorter-term stabilization process also may have unforeseen adverse environmental and social impacts. For example, general reductions in government spending are often required to limit budgetary deficits and bring inflation under control. However, unless such cutbacks are carefully targeted, they may disproportionately penalize expenditures on environmental protection or poverty safety nets (Barcena *at al.* 2002). Another important linkage is the possible short-term necessary impact of adjustment on poverty and unemployment, whereby the poor are forced to increase their pressures on fragile lands and "open access" natural resources -- due to the lack of economic opportunities elsewhere. In this case, appropriate measures designed to address the possible adverse consequences of adjustment will be justified -- on both social and environmental grounds.

Finally, economywide policies will have additional longer-term effects on sustainability, whose net impacts are less predictable. Some of these effects need to be traced through a general equilibrium framework that captures both direct and indirect links. For example, adjustment-induced changes often succeed in generating new economic opportunities and sources of livelihood, thereby alleviating poverty and helping to break the vicious cycle of environmental degradation and poverty. Higher incomes tend to increase the willingness-to-pay for better environmental quality, which will lead to better protection of the environment. However, while such growth is an essential element of sustainable development, it will necessarily increase the overall pressures on environmental resources. At the same time, properly valuing resources, increasing efficiency and reducing waste, will help to reshape the structure of economic growth and limit undesirable environmental impacts. Finally, environmental policies themselves could have impacts on income distribution and employment.

Many of these conclusions are illustrated by the use of CGE models applied to developing countries, in recent publications by *Persson and Munasinghe 1995, Dessus and Bussolo 1996, Munasinghe 1996, Rodríguez et al. 1997,* and *De Miguel and Miller 1998*.

More generally, since the first environmental CGE models appeared (*Forsund and Strom 1988, Dufournaud et al. 1988, Bergman 1991*), the recent literature includes applications in many major areas, such as a) models used to evaluate the effects of trade policies or international trade agreements on the environment (*Lucas et al. 1992, Grossman and Krueger 1993, Beghin et al. 1996, Madrid-Aris 1998*, Yang 2001, Beghin et al. 2002) or diverse applications in the area of the Global Trade Analysis Program (Hertel, 1997); b) models used to evaluate climate change, which are usually focused on the stabilization of CO_2, NO_x and SO_x emissions (*Bergman 1991, Jorgenson and Wilcoxsen 1993, Li and Rose 1995, or Rose and Abler 1998, Edwards and Hutton 2001*); c) models focused on energy issues, which usually apply energy taxation or pricing to evaluate the impacts that changes in the price of energy can have on pollution or costs control (*Piggot et al. 1992, Rose et al. 1995*); d) natural resources allocation or management models, whose objective is usually the efficient interregional or inter-sectoral allocation of multi-use natural resources -- for example, allocation of water resources among agriculture, mining, industry, tourism, human consumption and ecological watersheds. (*Robinson and Gelhar 1995, Mukherjee 1996, Ianchovichina et al. 2001*); and e) models focused on the evaluation of the economic impacts of environmental instruments, or of specific environmental regulations as the Clean Air Bill in the USA (*Jorgenson and Wilcoxen 1990, Hazilla and Kopp 1990*).

Finally, double dividend issues have been a recent hot topic, where CGE models have been increasingly applied. The theory of optimal taxation in the presence of externalities, i.e., the environmental taxation based on Pigou principles (Auerbach 1985) has been in continuous discussion both under theoretical grounds and by empirical studies (Bovemberg and de Mooij 1994; Bovemberg and Goulder, 1996; Goulder *et al.,* 1997; Jaeger 1999). Repetto *et al*. (1992) showed in a partial equilibrium framework that "green" tax reforms can improve the welfare in the economy by recycling the revenue to reduce distorting taxes. The debate on the existence of a double dividend derived in the necessity of applying general equilibrium frameworks. Thus, CGE models have been used to argue in favor or against the existence of a double dividend (Bovemberg and de Mooij, 1994; Goulder, 1995; Bovemberg and Goulder, 1996; Fullerton and Metcalf, 1997; Bento and Rajkumar 1998; Bosello, Carraro and Galeotti, 1998; Parry and Oates, 1998; Koskela, Schöb and Sinn, 1999; Parry and Bento, 1999, etc).

Applications in Chile

The applications of computable models of general equilibrium for Chile are few. In general these applications have been dedicated to analyze the effect of changes in tariff policies, arising from the debate on trade agreements among Chile and MERCOSUR, NAFTA, European Union, United States of America and Asia-Pacific. Other models have tried to analyze the effects of taxation policies on the rest of the economy and its possible changes. In the case of tariff policy analysis, there are two computable general equilibrium models: by *Coeymans and Larraín (1994)* and *Harrison, et al. (1997)*. Both models use similar techniques to analyze the effects of different trade agreements signed by Chile.

Coeymans and Larraín (1994) carried out a study of the consequences of Chile joining NAFTA. The model is set up for a small and open economy (SOE), and includes six productive sectors and 3 regions that trade with each other (Chile, U.S., Rest of the World or ROW). Data used for this study comes mainly from the I/O table of 1986. The results indicate that an agreement between Chile and the U.S. would generate a new pattern of trade composition with the U.S. and that in general, a series of benefits would follow the agreement. On the other hand, *Harrison, Rutherford and Tarr (1997)* built a model that uses the database of the GTAP program (Global Trade Analysis Project)[4]. This multi-regional model, with 11 regions and 24 productive sectors, is used to analyse the entry of Chile to MERCOSUR, NAFTA, European Community and the Rest of South America (RSA), and the effects of trade re-routing. The results of the study are interesting since they indicate that such free trade agreements are sometimes beneficial to Chile, and sometimes not. Harrison, Rutherford and Tarr (2002) applied the same model to assess the Chilean process of sequentially negotiating bilateral free trade agreements. The article focuses on the importance of market access and lowering tariffs.

A third study, *Ruiz and Yarur (1990)*, analyzes by means of a recursive dynamic SOE model, the effects on the economy of a change in taxation policies. This study uses data from the I/O 1977, to analyze the effects on the economy of the change in different taxes. The work of *Bussolo, Mizala and Romaguera (1998)* tries to analyze the effects of trade agreements focusing on the labour market. The model includes 24 productive sectors and 7 occupational categories that are based on the updating of the SAM from 1986 to 1992. The article analyzes the effects of a tariff reform in two ways. In the first place, a competitive labor market is assumed, and later this assumption is relaxed by introducing certain rigidities (changes in salary negotiation and minimum wages).

Focus on agricultural issues, Holland et al (2002) applied a CGE to analyze the impacts of agricultural reforms consisting on price band removal and on eliminating all tariffs on agricultural and food commodities in Chile. Urban employment, rural-urban migration and welfare effects are addressed.

Among the CGE models applied to environmental issues in Chile is the model by *Beghin et al. (1996*) - an application of the TEQUILA model developed by the OECD development center. This study endeavors to analyze the environmental impact of carrying out environmental policy, trade liberalization and trade agreements by means of a dynamic computable general equilibrium model. For this purpose, a multi-regional model that includes 26 regions and 72 productive sectors is built.

The analysis determines the emissions from estimated productive activity at the national level, and scaled for Santiago. On the other hand, using a linear dispersion model for air pollutants, the air concentration of particulate is estimated for Santiago. Finally, by means of dose-response functions this concentration is translated into indexes of mortality and morbidity. The results indicate that particulate material as well as SO_2 and NO_2 are complementary in the economic activity, and that their abatement produces a larger effect in the reduction of mortality and morbidity. Nevertheless, the analysis of the eventual entry of Chile to NAFTA appears to be beneficial for the environment, whereas the entry to MERCOSUR or a unilateral drop in tariffs will not. Taxing the above mentioned pollutants leads to increased emissions and concentrations of substitutes, which are also toxic, and bio-accumulative gases, causing a negative net effect on the indexes used for mortality and morbidity.

Beghin and Dessus (1999) applied a static version of the same model to assess the issue of double dividend under trade distortions. They explored double dividend in the sense of substituting trade distortions for environmental taxes.

[4] Project developed at Purdue University for the analysis of world trade, which has generated a global CGE model incorporating homogeneous SAMs for all the countries.

O'Ryan et al (2002) applied an adaptation of the OECD model to evaluate policy options for reducing air pollution in Chile. The model incorporated the recently published input-output matrix for Chile.

These last examples illustrate CGE applications to assess economic and environmental linkages. Nevertheless, in Chile, there has not as yet been any attempt to evaluate the interrelation between the social and the environmental spheres of sustainable development. Chapter 3 will address it by examining the cross effects of social and environmental policies for Chile.

2. ECONOMIC, SOCIAL AND ENVIRONMENTAL POLICIES IN CHILE

Since the mid-eighties and up to the end of the last millennium, Chile was considered an example for developing countries due to its rapid economic growth, based on an export-led development strategy. Additionally, significant reductions in poverty were obtained in that period. However, the environment has suffered severe stress and policies have been applied and enforce to reduce these pressures, only after the mid-nineties. In this section, the main economic, social and environmental issues and policies are discussed.

2.1 Economic Issues

During the eighties, Chile engaged in trade liberalization and extensive privatization programs, promoting exports and free markets as the main engines for growth. This trend continued in the nineties, albeit less strongly. The Government does not set prices, with the exception of public transport, some public utilities and port charges. Tariffs applied to countries without free trade agreements are basically uniform, and currently stand at 7%. A schedule has been set to reduce tariffs to 6% by 2003. Regulatory policies, though limited, have been improved in areas such as utilities, the banking sector, security markets and pension funds.

The main efforts in this period however, have been in maintaining macroeconomic stability, improving provision of infrastructure, and focusing resources to reducing many of Chile's unsolved social problems. Legislation is now in place to privatize ports, water and sewage, and will probably be pushed during the next few years. The main reforms implemented during the decade include privatization of public utilities; promotion of private investment in infrastructure, telecommunications, electricity and air transport; trade liberalization and trade agreement expansion; and reform of the educational system. In the future, a system of licenses probably will replace direct privatization.

The policies applied have been very successful; consequently economic performance during the nineties has been Chile's best in the last century. The country grew at an impressive 8% per year between 1989 and 1998. The 1997/98 Asian Crisis also shocked the Chilean economy, which experienced a small recession in 1999. Despite adverse international events (slowdown of the international economy, uncertainty after September 11th terrorist attacks, Argentinean crisis, low commodity prices such as copper, fishmeal and cellulose, and a higher oil price, etc), economic growth in 2000 achieved a remarkable 4.4% and decreased to 2.8% in 2001. Currently it is estimated to be around 3%. Regardless, Chilean performance far exceeds others in the region, which exhibit poor growth (between 0% and 1%). Per capita GDP surrounds 4.500 US$ at current prices.

Relevant variables (inflation, current account deficit, reserves, etc.) have been kept within acceptable limits. Since the beginning of the nineties, the Central Bank posts an inflation target for the year. As a result, inflation fell from 27% in 1990, to 2.6% in 2001. Government spending has been sensible, permitting fiscal surpluses each year up to 1999. Notwithstanding, when the country is suffering from an international situation that impacts negatively on unemployment rates, fiscal expansion has been moderated and the deficit will be easily balanced in the following years. The current account has been in deficit most of the decade, but has been easily financed by substantial foreign capital inflows, since

Chile's performance has made the country very attractive for investment. External debt composition has changed from 30% private debt in 1990, to 85% in 2002 and it is mainly medium and long-term debt (83%)[5]. Nowadays, external debt (US$ 38.989 millions) accounts around 57,6 % of the GDP.

Gross internal investment has increased significantly in the period, reaching 27% of GDP in 1998, a very significant increment compared to the 16% average of the eighties. However, internal savings have not grown much in the decade, and most of the increase in investment has been financed through foreign savings. After 1998, investment slowed down to around 22% of the GDP, paralleling a reduction in foreign savings.

As a result of this performance, real wages increased during the 90´s at an average rate of 3.2 %. Unemployment has fallen from an average of 18% in the eighties to 6% in the nineties. However, since 1999 unemployment has jumped to 10% and, despite government's efforts, it still remains at 9%.

Poverty has continued to decline, falling from 45% of total households in 1987 to 22% in 1998 and 20.6% in 2000. Although noteworthy regional differences remain, this is a very significant national reduction for such a short period of time. Income distribution is Chile's weak spot. The minimum wage, although increasing at a higher real rate than wages, was only 160 US$ per month in 2002 (or just around twice the value defined as the poverty line). The richest 20% of households received more than 15.5 times the income of the poorest 20% in 2000; the Gini coefficient was close to 0.58. This situation has remained unchanged since the 1960´s.

Finally it is important to note that historically, Chile's growth has been based on its natural resources, both renewable and non-renewable. Chile is the world's leading copper and iodine producer and a growing source of gold, lithium and other non-metallic minerals. Copper is the main export product, equivalent to around 40% of its total exports - which fell from 80% in the eighties, as a result of a continuous diversification of exports. Agricultural products, fish and fishmeal, forestry products and cellulose are other important export sectors that have grown very rapidly in the last decade. Imports are concentrated in capital goods and fuel/energy.

2.2 Social Policies

Since 1990, public expenditure on social issues has increased significantly, in order to reduce the high levels of poverty. Following the basic principle of equal opportunities and an acceptable standard of living for all of the population, social policy in the last decade in Chile has been geared to improving the programs and coverage of the health, education, and housing sectors. Also, an effort has been made to promote productive development in poor areas.

Three distinct periods can be identified in the evolution of social policies in Chile (*Schkolnik, M. and Bonnefoy, J. 1994; Baytelman et al. 1999*). During the first period (1950-1973) termed "Universal Policies", there was a gradual growth in public social expenditure, coverage and number of beneficiaries. Programs were designed to have universal coverage, and were basically aimed at health and nutrition, education, housing and sanitary infrastructure programs. However, these programs were usually underfinanced. Subsequent pressure on the government for more resources, caused severe fiscal deficits.

The second period (1973-1989[6]), called "Assistance and Subsidies", was undertaken during a period of intense economic and political reform. The provision of the services by the public sector was decentralized and the private sector was encouraged to produce and operate social services. Universal programs were reduced and expenditure focused on specific objectives. The main goal during this period was to eradicate extreme poverty, to provide mother-child care and basic services. Social expenditure was severely reduced in the period. However, there were important improvements in human development indicators such as child mortality, reduction of illiteracy, and schooling, among others.

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[5] Up to June 2002.

[6] Applied during the military government.

The third period, named “Integrating Policies”, began in the 1990's[7] and is currently in effect. Spending on social objectives has increased substantially. Social policies are focused on improving the quality of services, and implementing specific instruments aimed at developing skills in the low-income population. Social *investment* is preferred over assistance. This view is consistent with the new government's goals of economic growth and macroeconomic stability *together* with equality and poverty reduction, not merely as a consequence of growth.

Reflecting the new governments’ concern for reducing poverty and income inequality, social expenditure increased strongly during this decade. Between 1990 and 1998 public social expenditure grew by 88% (66% in per capita terms), almost 8.2% annual growth. This increase was much higher than the regional average for Latin America (5.5%) for the same period (*CEPAL, 1999, 2000*). Consequently, social expenditure has risen from 61% of total expenditure in 1990 to 70% in 2000. This increase in public expenditure in Chile was higher than the growth of GDP for the same period. Table 2.1 shows the evolution of social expenditure in Chile between 1990 and 2000.

Table 2.1. Public Social Expenditures 1990-2000 (Percentages)

	1990	1992	1993	1996	1998	2000
Health	15,3	17,4	17,8	17,7	17,9	17,6
Housing	8,1	8,7	8,6	8,5	7,4	5,8
Education	19,5	20,7	20,6	22,6	24,5	25,2
Social Security	49,0	44,7	44,2	41,7	40,8	41,5
Others*	8,2	8,5	8,8	9,6	9,4	10,0
Public Social Expenditures	100,0	100,0	100,0	100,0	100,0	100,0
Share of the total Public Expenditure	61,2	61,6	63,1	66,0	65,9	70,5

*Includes monetary subsidies and social investment programs oriented to priority groups.
Source: National Budget Office, Ministry of Finance.
DIPRES (2001) Series Estadísticas, Estadísticas de las Finanzas Públicas 1991-2000, pp. 41

For the Health Sector, intense reforms that changed both the structure and the financing of the health sector were introduced in 1980. These reforms fostered the creation of a private health system, parallel to the public health service. Commencing in 1990, new criteria for health policies were defined, which included care for the poorest groups, recovery of the public system and an increase in the quality of attention.

In order to achieve these goals, public investment and expenditure were increased substantially, and new legislation to reorganize the coexistence between the public and private systems developed. For example, the average sectoral investment in health during the 1990's increased six fold compared to the eighties, reaching 87 million dollars per year (*MINSAL, 1999*). Consequently, the notorious infrastructure deficit was significantly reduced, recovering part of the hospital capacity and an increase in the access to health, especially for the poor.

Despite these improvements, the public system is still weak. There is a need to focus more on vulnerable groups; it is necessary to decrease the wide gap between the expenditure by the beneficiary in the public and private sectors. Finally, discrimination based on risk of disease should be avoided in the private sector, since it shifts the burden of elders (80%) to the public system, which has to assume higher disbursements and lower contributions.

[7] The change in focus is coincidental with the change to a democratic government in Chile.

In order to achieve these goals the government has recently proposed a major reform in the public health, the AUGE plan, to be implemented during 2002. This plan guarantees at least 80% financial coverage of 56 major diseases for the whole population. The plan is estimated to cost the government over US$200 million a year. It has proposed to finance this reform with: higher taxes on diesel, alcohol and tobacco, efficiency gains, higher diesel car permits fee, and the elimination of the maternity subsidy[8]. This plan however, faces strong political opposition, particularly from the dedicated Physicians Association.

Chile's educational system has also suffered intense changes in the last two decades. Up to 1980 Chilean education was mainly public. At the beginning of the eighties, this system[9] experienced a profound reform which led to the decentralization of the administration of publicly funded schools, and was transferred to the Municipalities. The reform also allowed for a more active role for the private sector as a supplier of education, introducing a subsidy per student –which covers all operational costs. The main objective of this reform was to promote competition among schools to attract and retain students, which should result in increased efficiency and higher quality of education. This educational policy has allowed an increase in access to both elementary and high school education. However, this increase in access did not improve the quality of the education, and important differences between private and subsidized schools became increasingly apparent. Moreover, public expenditure in education was reduced during the 80`s, from 3.5% to 2.5% of GDP affecting particularly the poorest segments of the population.

In 1990, specific objectives were proposed for this sector: (1) Improve the quality of education; (2) Provide more equality in access to education; (3) Increase access to education; and (4) Promote the participation of the different sectors and institutions in educational development. These changes required a notable increase in public expenditure in education, resulting in an increase of 136% between 1990 and 1998 (*DIPRES, 2001*).

Most expenditure is channeled to elementary education, specifically for subsidies. Elementary education expenditure is almost 6 times higher than pre-elementary expenditures, and 2.6 times more than high school expenditure. In addition, in 1995 emphasis was placed on promoting general education of a similar quality for all, reforming high school education to be actualized and diversified, strengthening teacher training, modernizing management of educational systems, increasing investment in education using both public and private funds, and strengthening scientific and technological research. Prominence was given to significantly increasing teacher's salaries.

Between 1990 and 1998 the average educational years for the population over 15 increased from 9 to 9.7 years. In terms of quality, the SIMCE[10] tests of the past years have shown a systematic reduction in the gap between subsidized schools and private schools, as well as the gap between the municipal schools and the rest[11]. This public effort must be maintained.

Housing policy has also been a key issue in Chile's current development strategy. The general goal has been to reduce the housing deficit and improve the precarious conditions of the houses of the poor. As in the other sectors examined, housing policy implemented since the late seventies was focused on the poor, and emphasized a subsidiary role of the state, with private agents having an active role in the design, localization, and financing of the houses. The private sector also defined the standards, costs and quantity of houses. The State's main role was to channel direct and indirect demand for subsidies.

There were basically two housing programs in the early nineties: construction of social housing and sanitation of houses and neighborhoods. Sanitation consisted in urbanizing properties and placing property titles in order. The other main program was based on demand subsidies to sectors with a larger savings capability and access to mortgage (*MIDEPLAN, 1996*). In both cases houses were built by private construction firms. Nevertheless, while in the first program costs were set from the start, the second

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[8] In the present, the maternity subsidy is financed by the government and consists in four months of wages for all working women. The proposal would use 0.6% of the individual health funds to finance the maternity subsidy.

[9] University education is not considered.

[10] SIstema de Medición de la Calidad de la Educación (System to measure the quality of the education)

[11] For further results see *Gonzalez (1999).*

program could compete in price and quality to attract potential subsided-buyers. As this housing policy was underfinanced, the increasing demand for houses was not satisfied. As a result the housing deficit increased during the eighties.

Between 1990 and 1998 public expenditure on housing was around 1% of GDP. Housing policy in the nineties was aimed at reducing the deficit substantially and improving the instruments used. More importance was given to the active participation of beneficiary families in the design as well as in the execution and development of solutions. Private sector participation was encouraged, not only as constructors and financiers, but was also extended to incorporate solutions by NGO's and community social organizations.

As result of these policies there was an important increase in housing solutions in the 90s compared to the 80s. The largest budget was channeled through the program of Social Housing, particularly the Basic Housing Program and through the program's subsidies. In terms of focusing of the housing programs, MIDEPLAN[12] (1999b) shows that 53.5% of the benefits given out by the social programs were received by the poorest 40% of the population. The benefits received by the poorest quintile grew from 29.5% in 1996 to 32.1% in 1998.

There have also been important qualitative improvements. According to CASEN (1998), deficit of material (material damage) was reduced by 39%, while deficits in sanitation were reduced by 14% and deficits in houses with both problems decreased by 47%. Even so, there are still around half a million homes with some kind of qualitative deficit.

Finally, with regard to productive development in poor areas, in the 1980's little attention was placed on improving productivity. Promotion of production was focused on modern sectors of the economy, concentrating incentive policies on the exporting sector and bigger companies, which was consistent with the prevailing economic policy of the 80's. At the end of the eighties, direct support was given through subsidies for small and medium enterprises to keep them active due to their strong influence on employment. There was little concern for the reduced productivity levels, and inadequate attention was given to technological innovation, incorporation to the markets and modern schemes of production and management. (*MIDEPLAN, 1996*).

This changed during the nineties as the specific objective of policies in this area were to complement the development of policies undertaken in other areas of the State, with the goal of overcoming poverty. It is expected that through the use and development of their own potentials, persons and communities can improve their living conditions through a gradual and sustained process, while developing a process of social integration. These new criteria in social policies favored the creation of FOSIS (Fund for Solidarity and Social Investment) in 1990, which was aimed at financing the promotion of productive development of the weaker sectors of the economy. Another important consideration in funding has been that it must support all Regions, and has to be assigned and used with a high degree of decentralization. According to FOSIS (1997), close to 50% of investment for 1998 was assigned to Regions.

The slower economic growth of the past four years (1998-2001) required the government to focus on the unemployment issues. This has lead the government to create about 96.000 new jobs until May 2002 (*MINTRAB, 2002*), and subsidize hiring in order to reduce the high unemployment rate. Unemployment subsidy, although approved, is not still applied and amounts involved are exiguous.

Despite the improvements discussed above, the social security safety net in Chile is still weak. The gap between rich and poor is large in education, health, housing and other social areas. This requires that focalized public social transfers be maintained.

2.3 Environmental Issues and Policies

[12] Based on CASEN, which stands for characterization of social and economic conditions. It is a national survey which is held every other year and from which most social indicators are calculated.

Since the beginning of the century, Chile had developed a considerable amount of environmental regulations and standards up to 1990. These were of diverse nature, dispersed among different sectors, fragmented, and without any coordination among them. These regulations were reactions to specific environmental problems at a given time, and not part of a coherent policy. As a result, many of the regulations were not applied, due to the uncertainty as to their validity, and moreover, a high degree of non-compliance. Nevertheless, environmental protection received strong support in the 1980 Constitution.

Based on the deteriorated environmental quality, particularly in Santiago, and the need to have an effective environmental policy to defend exports against accusations of ecological dumping, the democratic government, elected in 1990, initiated the restructuring of the sector by setting up the Special Commission for Metropolitan Region Decontamination to improve Santiago's deteriorated environmental quality. A few months later, the National Commission for the Environment (CONAMA) was established. In 1994, the General Environmental Framework Law was passed. It reinforced the previous institutional framework by setting the foundations for the National System for Environmental Management. This institutional development also reinforced environmental expenditures. Thus, the environment related expenditures by CONAMA, Ministries of Economy and Mining and Forestry National Corporation are now 50 times more than in 1990 (Brzovic *at al.* 2002). The distribution of the expenditures by objectives is presented in table 2. Notice that "Other activities of environmental protection" includes expenditures in environmental management. It is also important to observe that environmental authorities regulate and control some activities instead of intervening directly, therefore environmental expenditures can be transferred to private sector (for example, in air emissions abatement).

Table 2.2: Environmental Expenditures by objective 1999-2001
(Thousands of US$)

	Objectives according to CEPA[1] 2000	1999	2000	2001[2]
1	Protection of Air and Clime	6,337	13,440	6,204
2	Management of liquid waste	12,960	17,428	3,833
3	Management and Protection of land, underground water and superficial waters	41,087	60,055	48,693
4	Noise Pollution Abattement	81	347	305
5	Waste's Management	45,568	43,754	5,352
6	Protection of the Biodiversity	41,922	39,654	20,305
7	Others Activities of Environmental Protection	149,332	127,292	70,747
	Total Environmental Expenditure	**297,286**	**301,970**	**155,439**

[1] Classification of Environmental Protection Activities and Expenditure
[2] Preliminary commitments.
Current values at the annual averaged observed dollar (B. Central)
Source: based on *Focus (2000)*

Despite these progresses, policies and programs for sustainable development still play a secondary role in Chile, resulting in the accumulation of many environmental problems, of which the most important are:

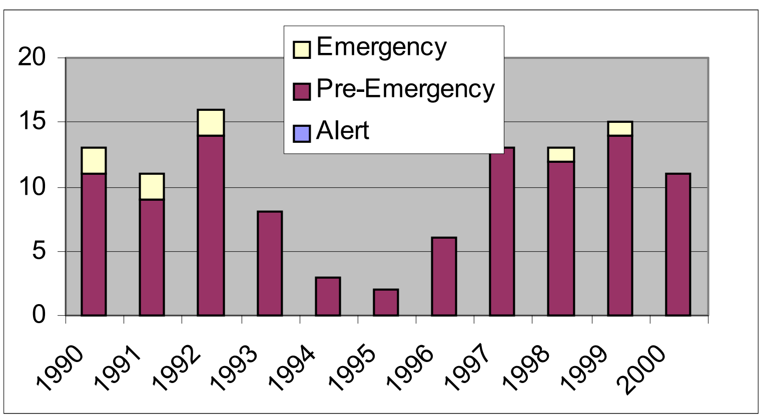
(a) Air pollution, linked to urban areas, industrial activities (pulp and paper, fishmeal), mining and electricity generation. In specific areas, emissions of different pollutants exceed the national normative or the international recommendations.

(b) High levels of water pollution caused by domestic and industrial effluents without treatment. This affects surface water, ground water and coastal seawater.
(c) Water scarcity at the regional level
(d) Inadequate urban development management, high levels of pollution, lack of green or recreational areas, etc.
(e) Inappropriate solid waste management and disposal, particularly hazardous wastes.
(f) Land erosion and degradation, associated to poor agricultural and forestry techniques, urban growth and inadequate solid waste management. This mainly affects agricultural land and river basins.
(g) Threats to native forest due to overexploitation (increase of forestry activity, coal making, wood collection) and absence of effective protection.
(h) Hydro-biological resource overexploitation and biomass exhaustion
(i) Poor management of hazardous chemical substances.

The rapid and unmanaged urbanization, fueled by economic growth, has led to moderately severe air and water pollution in many of Chile's cities. Preventive costs, health damages and productivity losses, particularly in Santiago, have been estimated as significant.

Air pollution in Santiago is the most obvious environmental problem in the country; however other cities are also being affected. For Santiago, natural variables, demographic growth, and both fixed and mobile air pollution sources are principal causes. The total amount of vehicles in Chile has grown from 1.1 million in 1990 to over 2.1 million by 2000. However, important reductions in PM10 and PM2,5 (23,3 % and 46 % respectively) have been achieved since 1989. The decontamination plan, elimination of 3.000 highly polluting buses, the incorporation of natural gas in the productive process of fixed sources, and introduction of catalytic converters in all new vehicles (as a result 50% of cars in Santiago had converters in 1999) are main determinants of this improvement. Nevertheless, in 1999 there were 14 environmental pre-emergency events, the maximum of the 90s, and one emergency event was declared[13].

Figure 1: Metropolitan Region Air monitoring System



Source: based on SESMA, www.sesma.cl

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[13] An Emergency Program is being applied since 1990. It establishes several levels of air quality. When pollution overcomes the 300-air quality index pre-emergency is declared, and emergency for 500 index. The level is associated to:

Index	CO ppm	SO2 µg/m^3	NO2 µg/m^3	O3 µg/m^3	Particulate µg/m^3
301-400	30	1.493	2.110	780	240
501 - >	50	2.620	3.750	1.400	330

The transport sector makes the largest contribution to air pollution. Transport is directly responsible for most of PM-10 emissions, the most critical environmental problem in the city: 25% are emitted directly and another 50% resuspended by vehicles on paved and non-paved roads. This sector is also responsible for 50% of PM2.5 emissions. Furthermore, the transport sector is also responsible for 94% of carbon monoxide (CO) emissions, 83% of nitrogen oxides (NOx) emissions, and 42% of Volatile Organic Compounds (VOC) emissions. Private transport is generally more polluting in terms of concentration of pollutants per vehicle mile traveled than public transport, except for PM10 emissions.

Table 2.3: Air Pollution in Santiago (1995)

Pollutant	**CO[b]**	**Ozone[c]**	**PM10[a]**	**PM2,5[a]**	**SO_2[a]**	**NO_2[a]**	**TSP[a]**
Max.	35.6	224	302	174	161	254	621
Min.	0.1	1	8	4	7	4	31
Average[14]	2.04	13	87	42	17.8	64.8	186.3

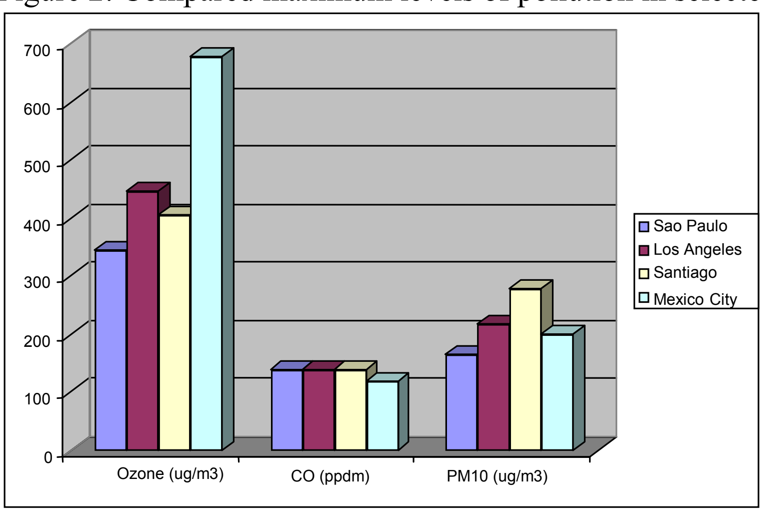
[a] data in µg/m3,[b] in ppm, [c] in ppb.
Source: SESMA, INE

Table 2.4: Air Pollution in Santiago (2000)

Pollutant	**CO[b]**	**Ozone[c]**	**PM10[a]**	**PM10-2.5[a]**	**PM2,5[a]**	**SO_2[a]**
Max.	19.3	162	230	105	153	135
Min.	0.1	1	5	1	4	1
Average[15]	1.1	16	87	35.8	34.8	4.7

[a] data in µg/m3,[b] in ppm, [c] in ppb.
Source: SESMA, INE

Figure 2: Compared maximum levels of pollution in selected cities (1995-1998)



Source: Alliende (2002)

However, air pollution in Santiago is subject to climate variables and pollution strongly varies among seasons, therefore annual average level can be meaningless.

Other problem areas in Chile include poor air quality in Concepción-Talcahuano from steel, petroleum, fishmeal, paper and pulp industries and high levels of ground level Ozone in Valparaiso-Viña

[14] The annual average is calculated as the annual average per month of all monitoring stations.
[15] The annual average is calculated as the annual average per month of all monitoring stations.

del Mar. In this sense, Talcahuano environmental recovery plan is operating and air monitoring systems are been established in several cities with the goal of identifying saturated zones. Other significant sources of industrial pollution are the use of fossil fuel, in addition to the pulp and paper industry in Regions VII through IX (sulfhydric acid), and fishmeal industry in VIII Region (sulfhydric acid and trimethylamine).

Table 2.5: Summary of Air quality in Chile's Major Cities

City	Region	Exceeds PM-10 Standard?	Other Pollutants with Problems?	Main emitting Sources
Arica	I	Yearly standard is exceeded	Probably sulfates	No information
Iquique	I	Daily standard was exceeded 8 times, an yearly standard exceeded	No	Fixed and mobile sources
Antofagasta	II	Daily standard was exceeded 2 times.	Particulates	No information
Valparaíso-Viña del mar	V	Daily standard was exceeded 3 times. Yearl average is very close to being exceeded	No	Mobile sources
Santiago	Metropolitan	Yes, daily standard was exceeded 138 time Yearly average exceeded	Yes, PM-2.5, Ozone and CO	Streets, vehicles, and industry
Rancagua	VI	Yes, daily standard was exceeded 11 time Yearly average exceeded	No	Mobile sources
Concepción	VIII	No	No	No information
Temuco	IX	Yes, daily standard was exceeded 9 times.	No	Fixed sources

Source: Summarized from *Universidad de Chile (2000).*

The biggest threat to health from air pollution comes from fine particles. Studies indicate that there are significant effects on human health. For this reason, several territories have been declared "saturated areas" for specific pollutants. Santiago Metropolitan Region was declared saturated of PM10, CO2, O3 and latent of NOx in 1996.

For air pollution, a compensation system for particulate material from large fix sources (volumes of up to 1000 m^3/hour) has been put into effect. Sources emitting less than their goal are able to sell their emitting capacity. Even though the system has been in place for four years, few trades have occurred. Moreover, there is a general –ideological more than technical- debate as to whether this instrument is appropriate in Chile. Also, public transport route tenders must compete for some of the most important roads used within Santiago. One key parameter considered in assigning these routes, is the emission characteristics of vehicles.

Waste generation in Chile is unevenly distributed within the Metropolitan Region generating 60% of domestic waste, while housing only 40 % of the population. The total production of domestic waste is also growing rapidly in Chile.

Water pollution is another problem for the country, together with severe **water scarcity,** which occurs in the northern regions and the Central Valley. Factors such as demographic growth, industrialization, and concentration of urban areas, have contributed to the deterioration of water volume and its environment. The problem is most serious in the north (mainly due to fishing and mining activities), the metropolitan region of Santiago and the central seaboard (sewage and industrial pollution) and coastal areas (Bay of Talcahuano – fisheries, petroleum, and pulp industries). The south experiences the setback of periodic flooding.

Studies show that the main water quality issue is microbiological contamination. While sanitation services are quite well developed in Chile, the *disposal* of collected wastewater is inadequate. Waste treatment facilities are very few and small in scale. The rivers running through Santiago and surrounding (especially coastal) areas are particularly affected by the dumping of untreated sewage into open watercourses.

Water pollution due to agricultural runoff is a concern, although there is little information on whether it is or not a problem. The use of water for agricultural, forestry, and aquacultural purposes, as well as the increase of human effluents in the lakes in southern Chile has significantly increased the growth of nutrients (acting as pollutants) in these water systems. This has led to a build-up of algae and a drop in biodiversity.

Centralization is also a problem which can hamper efficient regulation. Although decentralization efforts have been made, management of environmental policy in Chile tends to be concentrated in the center, with little concern for regional development priorities.

In conclusion, water and air pollution remain as important problems in Chile despite the increasing environmental expenditures, both public and private. The same is true for social issues. Remedies require both new policies to address environmental and social concerns, and improvement in the monitoring and enforcement of such measures. In the next chapter, this type of analysis will be done by assessing cross effects of social and environmental policies in Chile.

3. CROSS EFFECTS OF SOCIAL AND ENVIRONMENTAL POLICIES IN CHILE

From the previous sections, it can be concluded that there are many environmental problems that need to be tackled, in particular air pollution. Social issues are also a key concern and will continue to be in the next decade. Where should Chile start? Are there significant negative interactions or positive synergies between environmental and social policies? As mentioned earlier, the objective of this paper is to analyze the different links between environmental policies and their respective social effects, and alternatively the impact of social policies on environment.

To this end we first simulate an environmental policy: reduction of PM10 emissions through an emission tax in order to reduce 10% of total PM10 emissions. The same is done for SO2 and NO2 emissions. We then analyze the impacts on economic, environmental and social variables, concluding on which environmental policy/taxation is more effective. In the second step, we simulate the impact of a social policy. In order to attain this we simulate an increase in government transfers to households and then analyze its economic, social and environmental effects. Finally we simulate both policies simultaneously, maintaining public savings constant. The idea is to show up the interrelations of both policies knowing their specific impacts. Sometimes, by combining different policies we may not success in their individual expected effects. Alternatively, in other occasions, we may enhance the objective of one policy when applying a second one. We use the ECOGEM-Chile model, which is a CGE model for Chile, adapted from an OECD CGE model (*Beghin, et. al. 1996*). The CGE developed for Chile is a static model characterized by multiple sectors, two kinds of labour, quintiles of income, an external sector, and specified productive factors, among other features.[16] The model is savings-driven and includes energy-input substitution to reduce emissions. This is due to the fact that emissions are related to the use of different inputs and not only to production levels, as it is generally dealt with.

The main source of information is the Chilean social accounting matrix (SAM). The 1996 SAM was built on the basis of information from the Chilean Central Bank, mainly the newer 1996 input-output matrix. The matrix is measured in billions of pesos at 1996 purchasing power (O`Ryan*, et. al. 2001*).

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[16] The ECOGEM-Chile model, has been developed by DPP/INAP and CEA/DII of the University of Chile, is mainly the one generated at the OECD by *Beghin, Dessus, Roland-Holst and van der Mensbrugghe (1996)*, because abatement technologies has not been included in these simulations. For further details of the original model see *Beghin, et.al. (1996)* Technical Paper Nº116, OECD Development Center, Paris.

We assume zero capital mobility across sectors, pressing for intrasectorial adjustment in a short-run context. As for the income, substitution, and other elasticities, it is possible to choose long-term elasticities provided by the relevant international literature, giving more flexibility to the adjustment process and more realistic results. However, investment and capital accumulation processes as a function of relative returns may not be incorporated because this is a static model, and long-term elasticities will only minimize this flaw. With these parameters, the scenarios modeled here should account for medium term effects. Generally, we assume full employment, although we analyze the effects of considering high unemployment in one simulation.

There are two types of emission coefficients: input-based emissions coefficients and output emission coefficients. There are 13 different pollutants identified. First, toxic effluents are segregated by medium: air, water and soil (TOXAIR, TOXWAT, TOXSOIL). They contain mineral and industrial chemicals, fertilizers and pesticides, paints, etc. Next, three Bio-accumulative pollutants also by medium: air, water and soil (BIOAIR, BIOWAT, BIOSOIL). They contain metal elements such as aluminum, arsenic, copper, lead, mercury, zinc, etc. and they have a significant long-term risk to life. There is also five other air pollutants: SO2, NO2, VOC (volatile organic compounds), CO and PM10. Finally there are 2 other water pollutants: BOD (Biological Oxygen Demand) and TSS (Total Suspended Solids)[17].

3.1 Environmental Policy

We analyze the impacts of a reduction of 10% in PM10 emissions using emission taxes. This level of reduction is easily achieved without high abatement costs, compatible with the current economic context of high unemployment in Chile. Furthermore, the expected revenues associated to the environmental taxation are similar to the financial requirements for the employment policy. We replicate the same exercise for NO2 and SO2 emissions looking for efficiency gains and improvement of positive results (reducing negative ones). We do not compensate the higher public budget link to the environmental taxation revenues hence public savings grow. Therefore, new taxation appears in the economy without any other taxation/subsidy compensation. The results on macroeconomic variables are presented on table 3.1.

Table 3.1: Macroeconomic impacts of environmental taxation.

Taxation on:	**PM 10**	**SO2**	**NO2**
Real GDP	-0.2% [-0.1%]	-0.2%	-0.2%
Investment	0.8% [0.9%]	0.6%	0.7%
Consumption	-0.6% [-0.5%]	-0.5%	-0.6%
Exports	-1.1% [-1.0%]	-1.0%	-1.0%
Imports	-1.0% [-0.9%]	-0.9%	-0.9%

Note: results for PM10 simulation in a context of high unemployment are presented in brackets .

All results show moderate impacts on macro variables despite the adjustment process followed after the environmental taxation. Real GDP and consumption are moderately reduced, together with reductions in exports and import, which are close to 1%.

There are some significant sectoral impacts as observed in table 3.2. Emission taxes increase bill collection, raising public savings by around 14%. Despite household and enterprise savings (marginal) reduction, global savings rise. Increasing savings drive growth of investment, which is channeled to the economy mainly through the Construction sector. Thus, this sector increases its output by 0.7%. The Electricity sector also marginally benefits from these policies since part of energy demand swaps from oil

[17] Emission coefficients are obtained form *Dessus, et. al. (1994).*

and gas towards electricity (-0.1%-0.3%). Transport, oil and gas extraction, and oil refining suffer the highest negative impact in these simulations, reducing their sectoral output by 2.1%-2.3%, 4.1%-4.3% and 9.7%-9.8%, respectively. Impacts on other sector are negligible.

Table 3.2: Sectoral Impact of environmental taxation.

	PM 10	**SO2**	**NO2**
Construction	0.7% [0.8%]	0.6%	0.6%
Electricity	-0.1% [0.0%]	0.3%	0.3%
Renewable Resources	-0.7% [-0.6%]	-0.6%	-0.6%
Wood Products	-0.7% [-0.6%]	-0.6%	-0.6%
Gas	-0.8% [-0.7%]	-0.8%	-0.8%
Load & Pass Tpt	-2.2% [-2.1%]	-2.1%	-2.1%
Other Transport	-2.3% [-2.1%]	-2.2%	-2.2%
Oil and Gas Extraction	-4.1% [-4.0%]	-4.3%	-4.3%
Coal	-5.2% [-5.0%]	1.1%	1.1%
Oil Refinery	-9.7% [-9.6%]	-9.8%	-9.8%

Note: results for PM10 simulation in a context of high unemployment are presented in brackets.

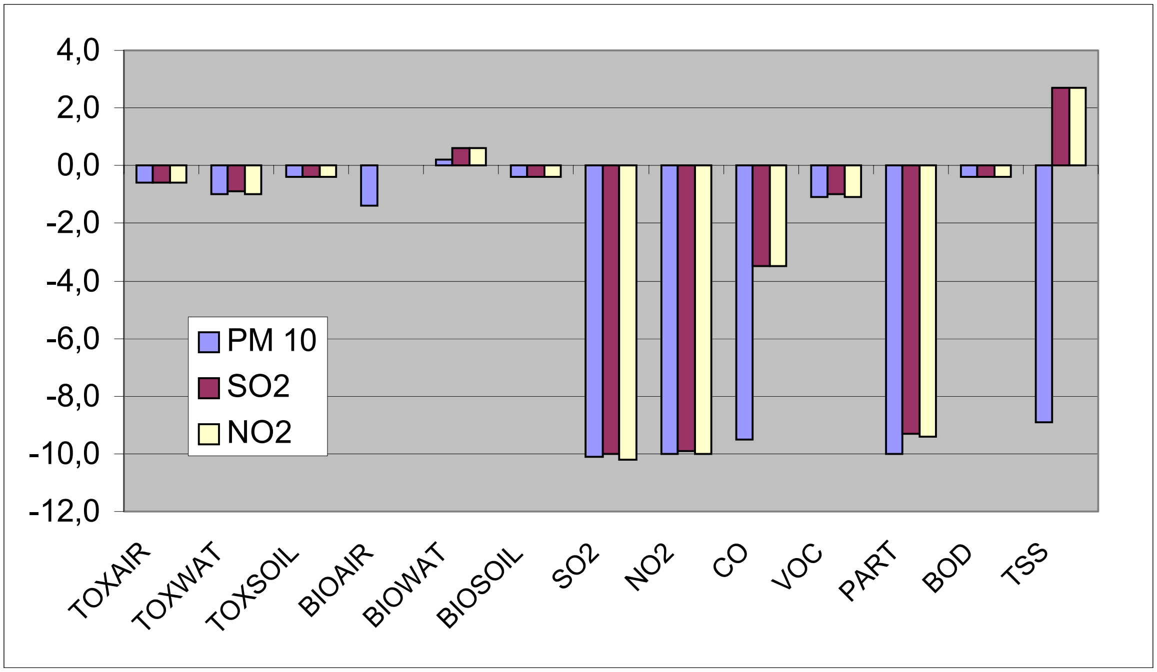
From an environmental point of view, it can be seen in table 3.3 and figure 3.1, that almost all emissions are reduced when taxing PM10 emissions. The sole exception is the bio-accumulative effluents into water, which marginally increase because of improvements in the construction sector. Furthermore, NO2 and SO2 emissions are reduced by over 10% when taxing PM10. The latter indicates strong links between different pollutants, especially among air pollutants. Taxing PM10 also shows superior environmental positive impacts than SO2 or NO2 taxation. The latter presents some increments on water effluents due to sectoral re-accommodation of production.

Table 3.3: Environmental Impact of environmental taxation

	10% reduction of PM 10	**10% reduction of SO2**	**10% reduction of NO2**
TOXAIR	-0.6%	-0.6%	-0.6%
TOXWAT	-1.0%	-0.9%	-1.0%
TOXSOIL	-0.4%	-0.4%	-0.4%
BIOAIR	-1.4%	0.0%	0.0%
BIOWAT	0.2% [0.3%]	0.6%	0.6%
BIOSOIL	-0.4%	-0.4%	-0.4%
SO2	-10.1%	-10.0%	-10.2%
NO2	-10.0% [-9.9%]	-9.9%	-10.0%
CO	-9.5%	-3.5%	-3.5%
VOC	-1.1% [-1.0%]	-1.0%	-1.1%
PART	-10.0%	-9.3%	-9.4%
BOD	-0.4%	-0.4%	-0.4%
TSS	-8.9% [-8.8%]	2.7%	2.7%

Note: results for PM10 simulation in a context of high unemployment are presented in brackets when different.

Figure 3.1: Environmental Impact of environmental taxation



Note: PM10 columns show the impacts on all pollutants when taxing PM10, the same applied for SO2 and NO2, respectively.

Table 3.4: Environmental Impact of PM10 taxation

	Total Effect	**Production Effect**	**Demand Effect**
TOXAIR	-0.6%	-0.6%	-2.8%
TOXWAT	-1.0%	-0.8%	-6.3%
TOXSOIL	-0.4%	-0.4%	0.0%
BIOAIR	-1.4%	-1.5%	-0.1%
BIOWAT	0.2%	-2.2%	0.7%
BIOSOIL	-0.4%	-0.4%	0.1%
SO2	-10.1%	-7.8%	-16.5%
NO2	-10.0%	-7.7%	-16.5%
CO	-9.5%	-8.5%	-16.3%
VOC	-1.1%	-1.3%	-0.0%
PART	-10.0%	-7.8%	-16.5%
BOD	-0.4%	-0.4%	-0.0%
TSS	-8.9%	-8.9%	-10.3%

Regarding social effects, the simulations show a slight – but not significant - increase in employment (which is related to the slight decrease in wages). Higher demand for labor in the construction sector, although offset by contractions in other sectors, explains this effect. A more positive effect on employment can be seen when (PM10) environmental taxation is applied in a high unemployment context. This is true because unemployment acts as productive sectors adjustment shield against new taxation.

There is also a moderate negative effect on all households' incomes. These are reduced in 0.6% for all quintiles –0.5% in case of high unemployment- when PM10 is taxed. For SO2 and NO2 taxation results are similar. Despite the latter, if another welfare measure is used -such as the utility functions-, we can observe that this policy is slightly regressive. The latter is explained because part of the enterprise adjustment to the new environmental taxation is carried out over the labor market (wages reduction) and consumer prices rise, which affects lower income consumption relatively more. This can be observed in table 3.5 and 3.6.

Table 3.5: Social Impact of environmental taxation

Real Disposable Income	**PM 10**	**SO2**	**NO2**
I Quintile	-0.6%	-0.5%	-0.5%
II Quintile	-0.6%	-0.5%	-0.5%
III Quintile	-0.6%	-0.5%	-0.6%
IV Quintile	-0.6%	-0.5%	-0.6%
V Quintile	-0.6%	-0.5%	-0.5%

Table 3.6: Impacts on utility of taxation on PM10 emissions.

	PM 10	**PM10 + Unemployment**
I Quintile	-0.6%	-0.5%
II Quintile	-0.6%	-0.5%
III Quintile	-0.5%	-0.5%
IV Quintile	-0.5%	-0.4%
V Quintile	-0.2%	-0.2%

Finally, we can observe that environmental policies may have at least some negative social impacts, especially in welfare. The utility function, which assumes a decreasing marginal utility -consistent with most economic models-, may contribute to the explanation[18]. Nevertheless, all benefits associated with the environmental quality improvement, such as reduction in health costs, productivity increments, reduction in defensive cost, etc., are not incorporated in the model. Therefore negative social impacts -and even economic ones- are over-valued.

The following conclusion can be made:

1.- The choice of the pollutant to be taxed is important: Taxation of some specific pollutants can reduce more the global pollution than taxing other effluents. Taxing PM10 emission we obtained superior environmental results than taxing SO2 and NO2, without worse macro, sectoral or social consequences.
2.- There are strong links between different pollutants. Therefore, careful assessments can contribute to improve the efficiency and efficacy of the environmental policy.

[18] $U = \sum_{i=1}^{n} \mu_i ln(C_i - \theta_i) + \mu_s \, ln\left(\frac{S}{cpi}\right)$

3.- Macro economic impacts are low and negative, but sectoral effects (positive and negative) can be strong. Therefore: a) flexible policy should be applied and adjustment periods must be considered, b) it is important to decide the use of the revenue arising from the environmental taxation. These new resources can be used to compensate the losers directly, or preferably, to reduce/eliminate a distorting tax achieving double dividends. Through careful targeting, tax reforms aimed at taxing bads instead of goods could reduce pollution without economical and social loses.
4.- Under a high unemployment context, an environmental taxation shock seems to be better absorbed by the economy because adjustment processes have more degrees of freedom in the short run. Thus, although a sole environmental taxation policy could enhance a negative situation under a crisis/recession context, tax reforms could be better applied.

3.2. Social Policies

The social policy simulated consists of an increase in transfers to households, in this case, by 8.4%[19]. The resources involved in this increment of transfers are equivalent to the cost of 100.000 new jobs created directly by the government –such as the employment plans actually put into practice-, which would reduce actual 10% unemployment to 8.2%. Currently, public transfers account for 23% of government expenditure; this increment would increase transfers to 25%. Transfer distribution shares among income quintiles are held constant. This increase in government expenditure is not counterbalanced by any additional revenue, hence government savings are reduced.

The macro effects of this simulation are very low. GDP is not affected. Investment falls by nearly 1% as due to the reduction of government savings (of more than 14%). On the other hand, consumption grows due to higher disposable income for almost all households. The construction sector is by far the most negatively affected, due to the reduction of investment. The machinery sector is also adversely affected, but it has a very small effect. On the other hand the gas, hydraulic/water and load and passenger transport sectors benefit slightly from the social policy.

Table 3.7: Impacts of a social policy consisting on an increment of transfers to households.

Macro Variables	Real GDP	0.0%
	Investment	-0.8%
	Consumption	0.4%
	Exports	-0.1%
	Imports	-0.1%
Sectoral Production Output	Construction	-0.7%
	Electricity	0.1%
	Renewable Resources	0.0%
	Wood Products	0.0%
	Gas	0.2%
	Water	0.2%

[19] This increment is consistent with the revenues obtained from the emission taxes on PM10 applied in the previous simulation.

	Load & Pass Tpt	0.2%
	Other Transport	0.0%
	Oil and Gas Extraction	0.0%
	Oil Refinery	0.1%
Households Real Income	Quintile I	3.2%
	Quintile II	1.7%
	Quintile III	1.0%
	Quintile IV	0.4%
	Quintile V	0.0%
Environmental Variables Emissions	TOXAIR	-0.1%
	TOXWAT	-0.1%
	TOXSOIL	-0.1%
	BIOAIR	-0.1%
	BIOWAT	-0.7%
	BIOSOIL	-0.1%
	SO2	0.1%
	NO2	0.1%
	CO	0.1%
	VOC	0.0%
	PART	0.1%
	BOD	-0.1%
	TSS	0.2%

Obviously social impacts are positive, with real income for almost all quintiles increases with the poorest improving most. Impacts on utility are very similar to those on income distribution.

Finally, in terms on environmental effect, we can notice slight increases in some emissions, mainly those connected to air pollution. Demand effect is generally negative for the environmental quality, although production effect –linked to the construction slowdown- is positive for the environment. However, all impacts are quite low, almost negligible.

In conclusion this specific social policy has very low impacts on environmental quality, although the sign depends on the specific pollutant.

3.3. Mixed Policies: Social and Environmental

In the previous exercises, the environmental policy applied did not have large social impacts, and the social policy applied had insignificant impacts on environmental variables. It was not possible to find a double dividend (social and environmental). Moreover, there seemed to be a trade-off among social and environmental policies/impacts. This trade-off can be even larger if stronger policies are applied.

In this section we explore joint social-environmental policies, which mitigate the negative impacts of policies applied independently. The final simulation in this paper is a mix of the two previous policies, i.e. a reduction in PM10 emissions of 10% enforced with emission taxes. The additional revenue generated by this tax is used to increase government transfers to households, keeping real government savings constant.

Macro-impacts are a mix of the results of applying social and environmental policies independently. The negative effect on consumption derived from the environmental policy is mitigated; on the other hand, the negative investment effect due to the social policy is offset. Macro-variables suffer from a slightly negative impact.

Table 3.8: Comparative Macroeconomic impacts.

	PM 10	**Transf.**	**PM10+Transf.**
Real GDP	-0.2%	0.0%	-0.2%
Investment	0.8%	-0.8%	-0.1%
Consumption	-0.6%	0.4%	-0.2%
Exports	-1.1%	-0.1%	-1.2%
Imports	-1.0%	-0.1%	-1.1%

At a sectoral level, environmental taxation maintains its relative importance on impacts, and winners and losers are almost the same as when applying only the environmental policy. Some exceptions are remarkable: Renewable resources, coal, food industry, oil refinery, gas, commerce, load and passenger transport, reduce their negative impact, and service and textiles become positive. Construction, as channel for investment, presents an averaged result (-0.1) between those obtained with the environmental and the social policy respectively. Positive environmental impacts remain the same as when the environmental policy was applied alone.

Table 3.9: Comparative Sectoral Impacts.

	PM 10	**Transf.**	**PM10+Transf.**
Construction	0.7%	-0.7%	-0.1%
Electricity	-0.1%	0.1%	0.0%
Renewable Resources	-0.7%	0.0%	-0.6%
Wood Products	-0.7%	0.0%	-0.8%
Gas	-0.8%	0.2%	-0.5%
Water	-0.1%	0.2%	0.1%
Load & Pass Tpt	-2.2%	0.2%	-2.0%
Other Transport	-2.3%	0.0%	-2.3%
Oil and Gas Extraction	-4.1%	0.0%	-4.1%
Oil Refinery	-9.7%	0.1%	-9.6%

Social impacts are also very positive: employment increases slightly and income distribution improves. Nevertheless, the wealthier 40% of the population reduce their real income. In terms of utility, the results are quite similar, but the wealthiest population hardly receives negative impacts.

Table 3.10: Comparative Social Impacts.

Real Disposable Income	**PM 10**	**Transf.**	**PM10+Transf.**
I Quintile	-0.6%	3.2%	2.6% (2.5%)

II Quintile	-0.6%	1.7%	1.1% (1.1%)
III Quintile	-0.6%	1.0%	0.4% (0.3%)
IV Quintile	-0.6%	0.4%	-0.2% (-0.1%)
V Quintile	-0.6%	0.0%	-0.6% (-0.2%)

Note: Utility levels presented in brackets.

Environmental impacts of the joint environmental-social policy are comparatively much better. Out of the 13 types of effluents, 9 reduce their emissions more than when applying only the environmental policy. In the other 4 cases, mitigation is close to the highest levels achieved by the separate policies.

Table 3.11: Comparative Environmental Impacts.

	PM 10	**Transf.**	**PM10+Transf.**
TOXAIR	-0.6%	-0.1%	-0.8%
TOXWAT	-1.0%	-0.1%	-1.1%
TOXSOIL	-0.4%	-0.1%	-0.6%
BIOAIR	-1.4%	-0.1%	-1.5%
BIOWAT	0.2%	-0.7%	-0.4%
BIOSOIL	-0.4%	-0.1%	-0.6%
SO2	-10.1%	0.1%	-10.1%
NO2	-10.0%	0.1%	-9.9%
CO	-9.5%	0.1%	-9.5%
VOC	-1.1%	0.0%	-1.0%
PART	-10.0%	0.1%	-10.0%
BOD	-0.4%	-0.1%	-0.6%
TSS	-8.9%	0.2%	-8.8%

In conclusion, it seems to be better to combine environmental and social policies. Macro and sectoral impacts maintain their effects in the worst scenario, but both social and environmental variables improve even more. Nevertheless, the small cross impacts suggest that policy-makers should focus on environmental/social policies separately identifying potential losers for later compensation or aside policies.

4. CONCLUDING REMARKS

During the nineties, Chile made strong efforts to improve environmental and social standards. Further improvements will have increasing marginal costs. Therefore, innovative new approaches should be taken; one possibility is to combine different policies so as to enhance positive cross effects or to mitigate the negative side effects of any specific policy.

This paper presents an empirical application of the computable general equilibrium ECOGEM-Chile to assess environmental and social linkages. The model incorporates the complex interrelations between the diverse sectors and agents of the economy, which facilitates the analysis of cross effects in environmental and social policies. Six different policies are simulated: three environmental different policies that impose taxes on air emissions, aiming to reduce 10% of total PM10, SO2 and NO2 emissions, respectively; one social policy that increases government transfers to households; and a mixed social-environmental policy package, where the environmental tax on PM10 and the social transfer policy are simulated simultaneously. In the latter, public savings are maintained constant, i.e., revenues from the environmental policy are allocated to social related fiscal expansion. Finally, the first simulation – PM10 taxation - was replicated in a situation of high unemployment.

In relation to the environmental policies, it can be concluded that taxing PM10 emission yields better environmental results than taxing SO2 and NO2, without substantial differences in the macro, sectoral or social results. It shows the strong links between different pollutants, which encourage policy-makers to analyze the pollutant to be taxed more specifically, to achieve optimal results.

Considering the "superior" PM10 environmental policy, the simulation shows that macroeconomic impacts are slightly negative, but sectoral effects (positive and negative) can be strong. Therefore, policy-makers should consider a flexible policy with adjustment periods. Nevertheless, tax reforms aiming to tax environmental bads instead of goods, seem to be able to achieve fairly good environmental results without economic and social loses.

Under high unemployment situations, an environmental tax shock seems to be better absorbed by the economy. This is true because firms have more degrees of freedom to adjust their production functions through the labor market. This does not imply that environmental taxation should be applied specifically during periods of economic recession or when labor markets are more flexible.

Regarding the social policy applied, the simulation shows very low impacts on environmental quality, although the sign depends on the specific pollutant. In conclusion, the evidence in this paper suggests that environmental policies (such as those applied here) may have social impacts, but not vice versa.

Since cross effects are relatively small, policy-designers should focus on the specific policy under consideration (environmental or social). Nevertheless, social and environmental policy-makers should coordinate among themselves, because it is possible to improve some results by combining both kinds of strategies. Thus, specific social policies may ameliorate negative sectoral and distributive effects of environmental policies, i.e., the mix of policies result may improve overall results. In this context, compensating policies for potential losers might increase their acceptance of environmental policies.

These results show that general equilibrium modeling, in this case through the ECOGEM-Chile model, is very useful for analyzing systematically and holistically, different economywide policies and their impact on the Chilean economy. Winners and losers may be identified with the potential magnitude of gains and losses. The results obtained are not all straightforward, i.e., indirect effects are relevant.

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ANNEX 1. Summary of the Computable General Equilibrium Model: ECOGEM-Chile

A1.1.- Characteristics of the model

Here, only the main equations of the model are presented, particularly those associated with environmental variables. The main indexes used in the model's equations are listed below:

i, j	Productive sectors or activities
l	Types of work or occupational categories
h	Household income groups (quintiles)
g	Public spending categories
f	Final demand spending categories
r	Trade partners
p	Different types of pollutants

Production: production is modeled by the CES/CET nested functions (i.e. constant elasticity of substitution – transformation). If constant returns to scale are assumed, each sector produces while minimizing costs:

$$\min\; PKEL_i KEL_i + PABND_i ABND_i \quad \text{s.t.} \quad XP_i = \left[a_{kel,i} KEL_i^{\rho_i^p} + a_{abnd,i} ABND_i^{\rho_i^p}\right]^{1/\rho_i^p}$$

In the tree's first level, decisions are made through a CES function to choose from a non-energy-producing intermediate input basket and a factor basket (i.e. capital and labor) together with energy producing inputs (KEL). In order to obtain the non-energy-producing intermediate input basket a Leontieff-type function is assumed. On the factors` side, the capital-energy basket and labor is split through a new CES function, and then energy is separated from capital, always assuming CES functions for substitution both between and within factors (types of labor, energy, and capital).

Income distribution: Production-generated income is allocated in the form of wages, capital returns and taxes among the domestic economy, the Government, and the domestic and international financial institutions.

Consumption: households distribute their income between saving and consumption through an ELES utility function (Extended Linear Expenditure System)[20]. This function also incorporates the minimum subsistence consumption as independent from the level of income.

$$\max\; U = \sum_{i=1}^{n} \mu_i ln\left(C_i - \theta_i\right) + \mu_s\, ln\left(\frac{S}{cpi}\right)$$

$$\text{subject to} \quad \sum_{i=1}^{n} PC_i C_i + S = YD \quad \text{and} \quad \sum_{i=1}^{n} \mu_i + \mu_s = 1$$

Where U stands for the consumer's utility; C_i is the consumption of good i; θ is the subsistence consumption; S, saving; cpi, the price of savings; and μ the consumption marginal propensity for each good and to save.

[20] The way in which savings are included (divided by a price index of the other goods) partially neutralizes the substitution between consumption and savings, because the savings` price is a weighted price of all the other goods. In this sense, savings represent future consumption.

Other Final demands: Once the intermediate demands and household demands are defined, there is only to include the rest of the final demands, i.e. investment, government spending and trade margins. Other final demands are defined as a fixed share of total final demand.

Public Finances: regarding public finances, there are different types of taxes and transfers according with the Chilean system. The following are defined in the model: direct taxation as labor tax (differentiated by occupational category), taxes on firms and on income (differentiated by quintile). Also import tariffs and subsidies are defined, together with export taxes and subsidies, (by sector), a value added tax VAT (for domestic and imported goods, and by sector) and some specific taxes.

As a closure condition for public finances, the model allows two alternatives: government spending is defined as fixed and equal to the original level previous to any simulation, allowing it to adjust through some selected tax or government transfer. Otherwise, government spending is allowed to vary, while taxes and transfers are kept fixed.

Foreign sector: to incorporate the foreign sector, the Armington assumption is used to break down goods by place of origin, allowing imperfect substitution between domestic and imported goods and services. The domestic supply gets a similar treatment, modeled by a CET function to distinguish between domestic market and exports.

For imports:

$$\min \; PDXD + PMXM \quad \text{subject to} \quad XA = \left[a_d XD^{\rho} + a_m XM^{\rho} \right]^{1/\rho}$$

where *PD* and *PM* are the prices of domestic and imported goods, while *XD* and *XM* are the respective amounts. *XA* stands for the good made up of both or the “Armington good”. Parameter ρ is the substitution elasticity between both goods.

For exports:

$$\max \; PD\,XD + PE\,ES \quad \text{subject to} \quad XP = \left[\gamma_d XD + \gamma_e ES^{\lambda} \right]^{1/\lambda}$$

where *PE* is the price of the exported good and *ES* is the respective amount. *XP* is the sector’s total production. Parameter λ is the substitution elasticity between both goods.

Factor Market Equilibrium Conditions: to achieve labor market equilibrium, labor supply and demand are made equal for each occupational category, where supply is determined on the basis of real wages. As for the capital market, a single type of capital is assumed, which may or may not have sector mobility depending on the imposed elasticity.

Short-term or long-term elasticities could be chosen for the substitution between the factor nest and non-energy-producing inputs, as well as for the CES between capital-energy and labor, between capital and energy, and for the various energy-producing sectors.

Closure Conditions: the closure condition for the public sector has already been anticipated. Also, as is usual in these models, the value of the demand for private investment must equal the economy’s net aggregate saving (from firms, households, government and net flows from abroad). The last closing rule refers to balance of payment equilibrium. This equation will be introduced into the model through the Walras Law.

A1.2.- Emission Reduction Within the Model

The model allows three possibilities to reduce emissions of pollutants in the economy. They all come from introducing some kind of tax or policy that alters the economic players' decisions in their profit or benefit maximizing processes. The most traditional and common one in general equilibrium models is the reduction in the production of the very pollutant sectors. The second is associated to the use of energy-producing inputs that discharge emissions into the environment whenever they are used in the productive process or in consumption.Allowing to substitute towards less contaminating energy-inputs, emissions could be reduced. Finally, emissions would be reduced by introducing "end of pipe" technologies (e.g. filters, treatment plants, and the like). The latter possibility is in an experimental stage and will not be included in the results of our simulations.

Not included is the possibility of technological change –from investment processes based on relative returns– towards environmental friendly technologies, because it would be necessary to use a dynamic model. Although it is possible to change substitution elasticities to simulate more flexibility to adapt technologies to less polluting processes based on cleaner inputs. Additionally, the consumers` utility function does not include the environmental quality as a good for which there is a willingness to pay (which may alter consumption decisions on the rest of the goods and their equilibrium prices).

Energy-producing inputs (i.e. coal, petrogas, petroref, electricity, and gas) are associated to the emission of 13 types of pollutants (not all of them discharged by the energy-producing inputs) through emission factors. Those emission factors link the use of each money unit spent in the input with the amount of emissions of each pollutant in physical units. Total volume of emissions in the economy for each type of pollutant is therefore determined by:

$$E_p = \sum_i \upsilon_i^p \cdot XP_i + \sum_i \pi_i^p \left(\sum_j XAp_{ij} + \sum_h XAc_{ih} + \sum_f XAFD_f^i \right)$$

that is, by the sum of all the emissions of the pollutant "*p*" caused by all the productive sectors "*i,j*" of the input-output matrix (74 sectors for Chile) generated in their productive processes *per se*, independently of the emissions associated to the use of polluting inputs, in addition to all the emissions derived from the use of polluting intermediate inputs[21] in the productive processes of all the sectors, in their consumption by households "*h*" and by other components of the final demand "*f*".

[21] Not only energy-producing.