



To trade or not to trade: Firm-level analysis of emissions trading in Santiago, Chile

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ABSTRACT

Whether tradable permits are appropriate for use in transition and developing economies—given special social and cultural circumstances, such as the lack of institutions and lack of expertise with market-based policies—is much debated. We conducted interviews and surveyed a sample of firms subject to emissions trading programs in Santiago, Chile, one of the first cities outside the OECD that has implemented such trading. The information gathered allows us to study what factors affect the performance of the trading programs in practice and the challenges and advantages of applying tradable permits in less developed countries.

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1. Introduction

Due to increasing climate change and local pollution, there is more and more interest in the use of tradable permits across the world. The efficiency of emissions trading systems relies on a number of major administrative issues concerning the role of the environmental authority for accounting, monitoring, and enforcement, and a proper understanding of the policy at the firm level (Hahn, 1989; Hahn and Hester, 1989; Stavins, 1995, 1998, 2003; O'Connor, 1998; Schmalensee et al., 1998; Salomon, 1999; Gangadharan, 2000; Tietenberg, 2002; Sterner, 2002; Bell and Russell, 2002; Stranlund et al., 2002; Krueger et al., 2003; Ellerman, 2005; Yates and Cronshaw, 2001).³ What happens if some of the basic conditions for an efficient market are not properly fulfilled? Chile was one of the first countries outside the Organization for Economic Cooperation and Development (OECD)⁴ to

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³ It is clear that many developing countries lack the resources needed for ideal market-based instruments, such as permit schemes, but they also, for the same reason, lack the ability to manage other policy instruments. Regulations also require monitoring, enforcement, and sanctions, as do taxes.

⁴ Chile is now (2010) set to accede to the OECD, but membership was quite distant when the trading program analyzed in this paper was launched in the early 1990s.

implement environmental trading schemes. In this paper, we examine this question by analyzing the Chilean experience with emissions trading schemes over the last 15 years.

The history of environmental policy in Chile is interesting. In spite of the fact that when pollution became an issue there was no environmental agency, the free market environment of the Chilean economy, the strong support for all forms of property rights (including those for air pollution by polluters) and a significant interest in the use of trading by the government led the authority to implement the first trading program in 1997⁵ to control emissions of particulate matter by stationary sources. Additional programs have been implemented since then, covering other stationary sources and pollutants, such as nitrous oxides (NO_x). Even if, at first glance, some Chilean trading programs seem to have reached their environmental objectives, the coexistence of high noncompliance rates and over-compliance by many firms indicates that the programs have not worked efficiently (Montero et al., 2002; Palacios and Chavez, 2005; Coria and Sterner, 2010).

The purpose of this paper is to identify the most important factors explaining this inefficiency. The programs suffer from various institutional failures, including a lack of publicly-available

⁵ The trading program was established by Supreme Decree 4 in March 1992. It became officially mandatory in 1994, but started in practice in 1997. Limited institutional capacity initially delayed system implementation. In fact, it was necessary to develop a comprehensive inventory of sources and their historical emissions before permits could be allocated. The process lasted five years and during that period, the regulator did not track trading activity, so there was no reconciliation of permits and emissions.

data on trades and prices. Hence, we had to find another way to tackle this research, and it seemed most appropriate to go to the actual sources. We conducted interviews and surveyed a sample of firms required to participate in the programs. We asked about the main obstacles involved in permit trading and to what extent the systems' pitfalls affected the firms' willingness and ability to trade. The information gathered allowed us to study to what extent the lack of institutions and expertise regarding market-based policies affects the performance of trading programs in practice. We believe that this will throw light on the broader issue of challenges and advantages of permit trading programs in less developed countries. The paper is organized as follows: The next section describes the trading schemes in use in Santiago. The third section describes the sample and the main results obtained from the survey. The last section reviews the lessons learned and concludes.

2. Trading schemes in Santiago: an overview

In 1992, a cap and trade scheme was implemented in Santiago to reduce emissions of particulate matter from large industrial and residential boilers (Montero et al., 2002; Palacios and Chavez, 2005; Coria and Sterner, 2010). At that time, there was no environmental agency, so a new governmental office was created to manage this program. The "Program of Control of Emissions Coming from Stationary Sources" (PROCEFF), under the Department of Health (SEREMI, Secretaría Ministerial de Salud), was given the responsibility of allocating permits and keeping an up-to-date record of permits, as well as monitoring and enforcing emissions caps. Within a short time, the first general environmental laws were passed, and in 1994 the National Environmental Commission (CONAMA) was created to coordinate all governmental offices involved with environmental jurisdiction (for example, the departments of transport, economy, and fisheries) and to design new policies to deal with pollution problems (Del Fávoro, 1994, pp. 40 and Pizarro, 2007). Since then, CONAMA has promoted implementation of additional trading programs for other stationary sources and pollutants. The actual implementation and management of these programs has however remained under SEREMI.

The fact that institutions and actual regulation evolved so quickly—in some cases simultaneously or even superseding legal bases—may have complicated implementation. Trading is officially "recognized" as a policy instrument by the law that created CONAMA. However, the law did not specify the allocation mechanisms, duration, or other characteristics of the permits schemes. Before this law, there was just a Supreme Decree, rather than a law, which established a specific program for large boilers. Although the large boiler decree was passed in 1992, the firms were only given permits and transactions recorded in 1997.

2.1. The large boiler program

The large boilers' program, which covered existing large boilers installed or approved before 1992, were endowed with particulate matter emissions permits called "initial daily emissions" (IDE). New large boilers, installed or approved after 1992, are required to offset their emissions fully through abatement in existing large boilers; in other words, new sources needed to buy permits from old ones. Thus, credits are created when existing large boilers reduce their emissions by more than a cap set by a pre-specified and individual daily standard, and they can transfer these credits to another existing or new source.

Sources trying to offset their emissions must request the offset and find a partner, signing an offsetting agreement (legalized by a public notary) specifying the emissions to be compensated and the sources involved in the transaction and finally, certifying the

level of emissions of each source in the transaction through formal monitoring procedures. After all this paperwork, SEREMI accepts or rejects the transaction or asks for additional information. If the transaction is accepted, a resolution grants the buyer a quantity of daily emission allowed.

Hence, although sources can propose trades, the final decision to create the credits and allow the transfers rests with SEREMI. In this sense, the program is an intermediate step between the early credit-based "bubbles" or "open market trading" schemes and the allowance-based cap and trade policies in the United States (initiated for sulfur pollution). In credit-based trading, credits can be created if one source reduces its emissions more than required by some pre-specified standard and transfers the credit(s) to another source, which can use them to offset its emissions. However, trading is confined by regulatory approval. On the other hand, in allowance-based trading, rights are initially created and distributed to sources, and there is no presumption that individual sources will limit emissions to the number of allowances they receive. They are free to trade allowances and the only requirement is that allowances equal emissions at the end of every compliance period (Ellerman, 2005).⁶

The daily cap on emissions of existing large boilers was calculated according to a formula that allowed them to emit a maximum rate, given by the maximum hourly gas flow rate (m^3/h) from their stack, an assumed emissions concentration of $56 \times 10^{-6}(\text{kg}/\text{m}^3)$, and an assumed operating time of 24 h per day. As the program progressed, the environmental authority realized that its initial allocation was too generous. In 2000 the targeted emission concentration was decreased to $50 \times 10^{-6}(\text{kg}/\text{m}^3)$, and again to $32 \times 10^{-6}(\text{kg}/\text{m}^3)$ in 2005. The offsetting rate—the number of permits that sources need to buy in order to emit 1 kg of particulate matter—was also modified. Initially, it was set at 1, but in 1998 it was increased to 1.2, and in 2000 to 1.5. All these changes imply a devaluation of the permits held and tougher demands for new sources since they are not granted permits.⁷ Besides, rules against trading pollution permits create a clear incentive to operate facilities longer, which, in turn, has a potentially negative effect on environmental quality (Maloney and Brady, 1988).

Permits were granted in "perpetuity" (but amendments to the quantities were made without compensation) and operators were restricted to trade permits on a *permanent basis*.⁸ This feature of the program makes banking and borrowing of permits virtually impossible and it is an important restriction in the structure of the

⁶ In practice, credit-based systems have been hampered by high transaction costs associated with the creation and transfer of credits and the process of regulatory approval. By comparison, trading observed in allowance-based (such as RECLAIM and Acid Rain Program) has been more active.

⁷ Notice that this rule implies that the number of permits is reduced progressively through trading, i.e., if 1 kg of particulate matter was traded after the year 2000, the buyer was allowed to emit just 0.67 kg. The changes in offsetting rates are applied to all the transactions occurring after 1998 and 2000, respectively, regardless of whether the buyer is an existing or new source. Nevertheless, if a firm granted with permits wants to shut down an existing boiler and/or industrial process and replace it with a new one, it can avoid such a depreciation of permits. This figure is known as "replacement".

⁸ The sale is not denominated in "tons of PM" but instead in "tons of PM/year". The buyer cannot just buy a ton for say 2010 but has to buy the "permanent" right to emit a ton of PM every year. As pointed out by Coria and Sterner (2010) and Montero et al. (2002), the main consequence of this feature is to reduce market liquidity since sources are uncertain about the availability of permits in the future. This may explain why buyers appear to pay prices close to their choke prices, even when there is an aggregate over-supply of permits. On the other hand, in the recent report by Tireole (2009), the author criticizes the European Emissions Trading System on similar grounds, for insufficiently clear property rights and rules concerning banking, free allocation to new projects, loss of permits in plant closure, excessive subsidiarity, and penalties that are not sufficiently credible.

property rights that differentiates this scheme from the SO₂ program in the US or the carbon rights in the European Emissions Trading System (ETS), where each permit equals 1 ton of emissions.

Existing boilers that do not use their IDEs or that exit the market have two and three years, respectively, to sell their permits before they become void. Therefore, IDEs have an expiration date and sources are not allowed to save credits indefinitely for future use or sale. This feature has caused many permits to become void so far.⁹

Sources must self-report emissions to SEREMI once a year. If they do not comply with the reporting requirement, they risk administrative sanctions. Sanctions range from a note of violation to a wide range of lump-sum monetary penalties (from US\$ 4.50 to US\$ 90,000 per Palacios and Chavez, 2005, pp. 459). The level of the final sanction depends on a case-by-case examination that considers the extent of the emissions and the degree and duration of the violation, among other things. In addition, temporarily shutting down a source's operation is also possible, although infrequent.

2.2. Regulation of large industrial processes

Two additional emissions trading programs were implemented in 2004 for particulate matter and NO_x pollution by large industrial processes.¹⁰ As in the large boiler program, existing sources were granted permits, but this time yearly caps on emissions were set on a target cap based on 1997 emissions levels. The formula allowed industrial processes to emit a maximum of 50% of actual 1997 of particulate matter emissions and 67% of 1997 NO_x emissions, and was calculated to reach the target by May 2007. (For NO_x, a second, more stringent target of 50% was also imposed for 2010.) These new programs shared most of the features of the large boiler program, with one important exception: short-term offsetting was allowed. Thus, industrial processes in need of emission permits could "rent" emission permits from other industrial processes in the program for a minimum period of one year.

The main motivation behind short-term offsetting was to help start up a market by sending price signals, while giving new sources access to permits, because initially there was a lower level of aggregate NO_x emissions. Calfucura et al. (2009) highlighted the effect of the lack of natural gas in explaining this shortage. The emissions cap was calculated in 1997, just after many industrial processes switched to natural gas. However, in 2004, Argentina restricted exports of natural gas to Chile to deal with domestic shortages. Many industrial processes reverted back to dirtier fuels, significantly increasing NO_x emissions and aggregate noncompliance with the emissions cap, as shown in Table 1.

Although the NO_x trading program granted a number of permits equivalent to 50% of NO_x emissions in 1997, actual emissions in 2005 considerably exceeded this target. Therefore, the program had a significant level of noncompliance.

The picture is similar to the case of particulate matter. As shown in Table 2, the aggregate level of noncompliance is mainly explained by new sources, which did not offset their emissions with emissions permits.

3. Data and results

The aggregate figures indicate severe imbalances in the permit market. However, additional detailed aggregate data on prices or transactions to help us answer questions regarding the effect of the

⁹ In fact, Coria and Sterner (2010) reported that 15.8% of the total initial permits granted in 1997 have become void.

¹⁰ That is, those industrial processes emitting more than 2.5 tons per year of particulate matter and/or more than 8 tons per year of NO_x.

Table 1
NO_x Emissions from large industrial processes.

NO _x 's emissions from large industrial processes	
NO _x ' emissions in 1997 (tons per year)	8480
NO _x ' emissions in 2005 (tons per year)	6877
Existing processes	4897
New processes	1980
Emissions 2005/Emissions 1997	81%

Source: Gamma (2007).

set-up of the schemes do not exist, so we turned to a more detailed firm-level analysis. After a set of exploratory interviews with policymakers, brokers, and 10 firms¹¹, we developed a questionnaire that we applied in person to 50 firms between December 2008 and April 2009. Through the exploratory interviews, we were able to classify the most important factors underlying the inefficiency of the trading programs into four groups:

1. Lack of information about permit prices
2. Lack of information about penalties for violation
3. Regulatory uncertainty introduced by changes in the rules
4. Incoherent institutional arrangements that divided the management of the trading program between two different governmental offices with different goals and agendas¹²

As described in Table 3, the 60 firms interviewed are 14% of the total number of firms, and 26% of the total number of stationary sources, involved in trading programs in Santiago, Chile.

According to the firms answering the questionnaire, 51.8% (114) of the surveyed sources are boilers emitting particulate matter, 31.5% (70) are industrial processes emitting NO_x, and 16.7% (37) are industrial processes emitting particulate matter. Our sample hence includes firms having "existing" sources endowed with (grandfathered) emission permits and/or "new" sources that are required to fully offset their emissions.

Table 4 describes some of the features of the sampled firms in terms of compliance, emissions trading, and size.¹³

Although firms were selected to provide a representative sample¹⁴, response rates can always introduce bias, in the sense that firms willing to answer may be distinct from the average. Our sample seemed to include firms that were more knowledgeable about the programs. (There were a larger number of sources per firm and a greater experience with or higher rate of offsetting; 66% of the surveyed firms have trade versus 27% of overall firms in

¹¹ The exploratory interviews took place in November 2008. We are thankful to Gianni Lopez (formerly with CONAMA), Jorge Caceres (formerly with CONAMA), Alejandro Cofré (broker, formerly with PROCEFF), Claudia Blanco (CONAMA), Yvonne Soler (broker), Julio Palma (broker), Eduardo Correa (consultant, formerly with CONAMA), Jaime Dimarca (Sociedad de Fomento Fabril, SOFOFA), Ian Nelson (METROGAS), Marina Hermosilla (POLPAICO), Paola Gandela (GERDAU-AZA), Victor Irrigoy (MOLIMET), Darinka Diaz (PROACER), Jose Ramirez (LANERA CHILENA), Sergio Berrios (TINTORERÍAS KREISSEL), Marcelo Alvarez (Fabrica de Papeles CAR-RASCAL), and Juan Larenas (CAROZZI).

¹² See Coria and Sterner (2010) for a detailed description of the trading programs in Chile.

¹³ The environmental authority records noncompliance and trading activity at the source level, and there is no official information at the firm level. In order to create such estimates, we used the fact that on average each firm has 2.5 sources. Thus, for example, to estimate the number of firms that have traded, we divided the number of sources that have traded by 2.5. The ratio is calculated by dividing the number of firms that have traded by the total number of firms in the program. The same procedure is used in the case of noncompliance.

¹⁴ Firms were first contacted by phone, based on a random procedure, and invited to participate in this study. After that, the questionnaire was conducted in person at those firms that accepted the request to participate.

Table 2

Aggregate shortage of PM permits in 2008.

Surplus/Shortage of particulate matter's emissions (tons/year)	
Existing sources	156.8
New sources	–539.9
Aggregate shortage	–383.1

Source: Centro Mario Molina (2008).

trading programs.) This needs to be taken into account, but is not necessarily unexpected. The program is complex and some smaller firms, which have not traded and do not understand how it works, might have felt they had little to contribute and declined to be interviewed.

Table 5 summarizes the trading activity of our respondents. Of the sample, 52% had sold emissions permits, while 62% had bought emissions permits. Not surprisingly, the trading activity was more frequent in the particulate matter program, since the boilers' program had been in effect for a longer time (more than ten years) than the NO_x program.

In the rest of this section, we discuss the primary findings of our questionnaire under five separate headings: market information, sanctions and penalties, regulatory uncertainty, institutional arrangements. Finally, we discuss the relative importance of the shortcomings of the programs.

3.1. The lack of market information about partners, prices, and technological options

Due to the public-good nature of some information, the market tends not to provide enough, so the government may need to consider collective action to obtain it. Harrison (1999) highlighted the role of U.S. Environmental Protection Agency's annual auctions and publicly-available reports of early trades and regular brokers' reports. They significantly contributed to the functioning of the permit market in the initial stages of the sulfur dioxide (SO₂) program in the United States by offering price information needed to make investment and compliance decisions.

SEREMI is, in principle, in charge of keeping updated records of valid permits, as well as information on trading procedures. It does keep paper records, for instance, of requests to sell permits. However, in practice, each trade is a complicated "case" that takes months to resolve and the actual price (if indeed there is a transaction) does not need to be officially reported. The agency merely gives authority to trade: as a result, there is no marketplace and no systematic record of previous transactions for firms. Furthermore, firms are not required to give the price of the emissions trade. Because many transactions occur between various sources of the same firm, there may not even be an explicit price. SEREMI, therefore, is incapable of providing any simple, accessible summary data on trades and prices.¹⁵ Although some brokers have fulfilled part of these needs—and thus reduced transactions costs, while absorbing some costs as fees over the last years—a significant number of sources that told us they still had no idea what permit prices were and mentioned this as a barrier that might prevent them from trading.

¹⁵ Somewhat ironically, Chile's environmental agency and many firms have asked one of the authors for overview information about trading.

¹⁶ The large rate of "intra-firm" trading partly explains the lack of historical information about prices. As reported by Coria and Sterner (2010), around 76% of the transactions corresponded to intra-firm trading (within firms), while 24% corresponded to inter-firm trading (between firms).

Table 3

Sample firms and sources of pollution.

	Exploratory interviews	Questionnaire	Total interviewed	Overall Rate
Sources	68	221	289	1096 26%
Existing boilers	15	76	91	442 21%
New boilers	6	38	44	294 15%
Existing processes NO _x	9	51	60	137 44%
New processes NO _x	2	19	21	60 35%
Existing processes PM	29	26	55	85 65%
New processes PM	7	11	18	78 23%
Firms	10	50	60	433 14%

In spite of a fairly high percentage of trading activity in our sample, we found that most respondents were unable to give estimates of the actual trade prices (less than 25% were able to give any price data for either selling or buying).¹⁶ Furthermore, because these data in principle must have referred to transactions at different dates, we did not find them useful for our analysis. However, we also asked firms to estimate the current permit price at the time of the interview. We found a fairly high amount of uncertainty concerning current prices. More than 30% of the respondents were unable to give estimates. In the particulate matter program, the highest estimate was eight times the lowest estimate, while in the NO_x program highest to lowest ranged from 1:4 (see Fig. 1). The average price in the particulate matter program was US\$ 6718/kg and in the NO_x program, US\$ 12,990/ton.

According to brokers, current market prices are US\$ 7850 for 1 kg of particulate matter and US\$ 9600 for 1 ton of NO_x. Hence, it seems that prices are on average underestimated for particulate matter, while it is overestimated on average for NO_x. There seems to be a negative correlation between the errors in price estimation and trading activity, in other words, firms that have made trades have better information of prices. However, the correlation is not significant, and a chi square test of the null hypothesis that firms that trade have better price information is also rejected.¹⁷

Brokers also mentioned that prices have increased significantly during the last years due to the natural gas crisis. Indeed, in 2005 the prices of 1 kg of particulate matter and 1 ton of NO_x were US\$ 5230 and US\$ 7850, respectively. Note that the permits are valid in perpetuity. This makes it difficult to compare the prices in Chile with other countries, where regulations are defined in tons. However, as a simple example, we can compare the price of NO_x emissions with the emissions taxes in Sweden and France by calculating a rental price of 1 ton NO_x, using a 10% discount rate. This would give a price of around \$1300/ton, which can be compared to the tax rate in Sweden (\$4000) and France (\$38). The Swedish tax is very high compared to all other schemes, and it is thus reasonable to say that the Chilean permit price is also fairly high.

Given the discussion above, it seems clear that price information is underprovided in these markets. This is also corroborated by the fact that virtually all respondents wanted more information, and 90%, for instance, said they would like to have a data management system, where firms could find information about potential sellers and buyers and prices. Also, firms stated that they wanted better (more) information. Of the respondents, 62% stated that most of the

¹⁷ All test results are available from the authors upon request. Throughout the paper, we used non-parametric tests (chi square- and Wilcoxon-Mann-Whitney tests), to account for our variables being categorical or ordered. The chi square- and Wilcoxon-Mann-Whitney tests are tests of distribution; however, detailed examination of the data allowed us to also draw inference on the means.

Table 4
Sampled firms and basic statistics.

	Surveyed firms	Overall firms
Noncompliance	36%	31%
Offsetting	66%	27%
Number of sources	4.4	2.5

information they do have has been gathered on their own initiative rather than coming from the authorities.¹⁸

Firms also stated that they wanted more information on options to offset emissions, abatement technology, and how to find partners for trading. Of the firms that have not traded, 71% said that if they needed to look for partners, they would do it by themselves or through brokers. On the other hand, in a free market, it is perhaps more surprising that as much as 29% would start by asking for assistance from SEREMI if they want to find a trading partner.

3.2. Lack of information on sanctions for violation

Stranlund et al. (2002) stressed the importance of prevailing market prices for the compliance incentives faced by firms in emissions trading programs.¹⁹ To guarantee that participants hold enough permits for their emissions, it is necessary that the expected penalty for emitting is far above the permit price; otherwise it would be cheaper to pay the penalty.

Beside the uncertainty concerning the current prices, we also found a fairly large uncertainty concerning the penalties to be imposed on sources in violation. Indeed, because the regulator SEREMI uses its discretion to determine the size of the penalty or whether a penalty is applied at all, we found that most of our respondents were unclear about the magnitude of the economic and/or administrative penalties related to noncompliance. For instance, 80% said they wanted the environmental authority to clarify the penalties.

When penalties for noncompliance are not clear and are at the discretion of the regulator, they can easily be manipulated (Peterson, 2003). This is particularly the case when noncompliance is explained partially by the delayed answer of the regulator to an offsetting proposal by firms! Thus, because of the delay in the regulatory process, sources can gain several months of “unpunished” noncompliance just by requesting transactions or introducing offsetting proposals. When it comes to this issue, we asked firms if they believed that “most firms comply.” We found (for particulate matter) that answers were quite evenly distributed between agreement and disagreement. For the NO_x program, however, the general belief was that most firms do not comply. In questions about penalties, a large fraction of the firms believed that non-compliers “face severe punishments,” including economic sanctions (64%). However, a large fraction of firms also said that there were ways for firms to escape penalties (48%), that some firms preferred to pay the economic penalties instead of complying with their permit level (64%), and that the economic and/or administrative penalties for noncompliance should be higher (60%).

¹⁸ 17% of the respondents stated that they have received most of their information from the environmental authority, while for 21% the industrial association has been the main source of information.

¹⁹ Naturally, there many other factors that can explain the compliance behavior as well. For example, Stranlund et al., (2008) examined the effects of risk aversion on compliance choices in markets for pollution control. He showed that in equilibrium a market for emissions rights with widespread noncompliance, risk aversion is associated with higher permit prices, better environmental quality, and lower aggregate violations.

Table 5
Sampled firms and trading activity.

	Selling		Buying		Not Trading
	Yes	No	Yes	No	
Particulate matter	48%	52%	58%	42%	38%
NO _x	14%	86%	16%	84%	82%
Total	52%	48%	62%	38%	34%

Interestingly, noncompliant firms agreed less about the existence of methods for firms to escape the penalties. Put another way, this means that compliant firms think that non-compliers escape penalties.²⁰

More than 60% of the respondents reported that it was not very costly to attain the regulated level for particulate matter or NO_x. Firms mainly achieved targets by switching fuels (39.4%), installing abatement technology, improving the efficiency of the sources (36.6%), and offsetting emissions (14%). However, 86% stated that compliance costs have increased significantly since the natural gas crisis, and 80% of the respondents said that noncompliance has increased due to lack of natural gas.

We found that 68% of firms said that SEREMI monitors firms continuously, although 70% would like SEREMI to increase its monitoring of sources in the trading programs. This is a striking number, and one is tempted to see it as the result of a permit-based approach. With old-fashioned regulation, it is very unusual to find sources of pollution who asked for more frequent monitoring. As soon as regulations are transformed into pollution rights, however, they acquire some of the attributes of “property” and become valuable. Many sources realized that their permits are valuable, especially when monitoring and the whole system in general is more stringent.

3.3. Regulatory uncertainty and changes in the rules

Property rights to the emission permits must be fully transferred for the market to work. Arbitrary regulatory interventions that affect the tenure of emission permits and hamper trade should be avoided. Unfortunately, this has not been the case with the Santiago programs. Changes in the rules and arbitrary interventions, such as changes related to rate of offsetting, reduction of EDIs, and expiration date, have been observed in all the programs implemented so far. We therefore took particular interest in studying whether firms knew about the changes and if changes in the rules hampered the willingness to trade and the liquidity of the market.

When it comes to the first question, firms were informed to a reasonable degree concerning the changes in the trading rules that have been implemented so far (see Table 6).

We inquired about the effects of the changing rules, focusing particularly on firms that did not trade permits. We found that 21.1% of the firms that have not traded permits preferred to keep permits in excess of their need, instead of selling them because “there is too much uncertainty about changes in the rules.” Some 36.8% did not trade because of planned expansion and 36.8% because they had not needed to trade so far.

According to our surveys and interviews, the main consequences of the regulatory interventions were that firms thought that the permit price will go up because the supply of permits is going down permanently (27.1%), and that industry will have to

²⁰ Using a non-parametric test (Wilcoxon-Mann-Whitney test), the distribution of the attitudes toward the statement “there are ways that firms escape the penalties” is shown to be significantly different between compliers and non-compliers ($p = 0.048$).

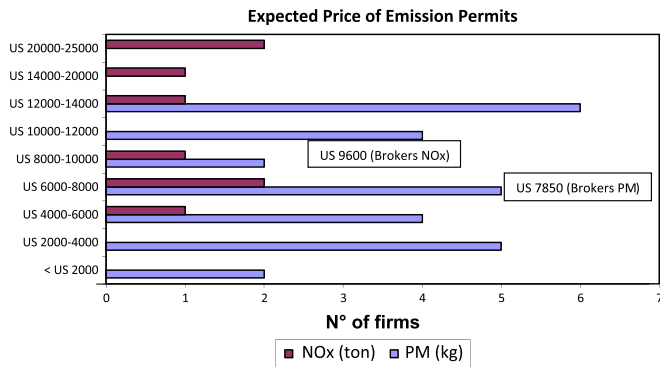


Fig. 1. Expected price of emission permits.

move out of Santiago (27.8%). However, a large fraction of firms believed that the changes will cause also ongoing investment in cleaner technologies (23.3%) and that eventually emissions permits will disappear due to the progressive reduction of permits every time they trade (21.1%).

3.4. The institutional arrangement

As mentioned in section 2, two governmental offices are involved in the development of trading schemes in Santiago. Chile's environmental protection agency, CONAMA, is at least partly responsible for the *design* of the trading policies, while SEREMI is in charge of actual implementation, monitoring, and enforcement of the policies. This institutional arrangement has created some agency problems (Pizarro, 2007) because SEREMI's performance is not measured by indicators related to the trading program, but by health indices. In addition, CONAMA and SEREMI tend to hold opposite views about how to deal with Santiago's air pollution problems. CONAMA wants to use flexible policies, such as trading schemes, while SEREMI is more concerned about the systematic increase in the health costs from pollution in Santiago (Calfucura et al., 2009). These two views affect the way they interact with firms: CONAMA has a more cooperative attitude than SEREMI when it comes to trading procedures, for instance.

Has the institutional arrangement affected firms' attitude toward the environmental authorities? It is common to find that firms are negative toward the environmental authorities that regulate them. In Santiago's programs, however, we found that firms were only moderately critical. In fact, they were quite divided on whether the environmental authorities were understanding and helpful to business interests or not. While both CONAMA and SEREMI received fairly neutral ratings, there were differences in attitudes between national firms (in terms of ownership) and international firms.²¹ National firms seemed to be more negative toward both environmental authorities.

Firms did not find the authorities helpful in facilitating permit trades. Of our respondents, 62% found CONAMA unhelpful, compared to 72% for SEREMI. Attitudes concerning collaboration were corroborated by their answers to questions about the purpose and effects of the program. Firms had a reasonable view of the main purpose of trading schemes. Mainly they cited "freezing emissions" (36.4%) and "promoting abatement" (30.3%), but also relocation of

²¹ Using a non-parametric test (Wilcoxon-Mann-Whitney test), the distribution of the attitudes toward the statement that firms agree to that CONAMA are helpful and understanding to business interests is shown to be significantly different between national and international firms ($p = 0.018$) while it is insignificant for SEREMI ($p = 0.118$).

Table 6

Sampled firms and knowledge about changes in the regulation.

Did you know about the change in?	Yes	No
Rate of offsetting	72%	28%
EDI's reduction	80%	20%
Expiration date	72%	28%

industry outside Santiago (16.7%). A few firms, however, mentioned the theoretical outcome of "meeting environmental targets at minimum cost" (13.6%).

Firms had mixed opinions on whether the schemes actually constrained industrial activities in Santiago. For the particulate matter program, only around half the participants agreed to the statement that the "permit programs prevented industry from growing in Santiago"; the NO_x program had a somewhat higher share of agreement. Many of the firms, however, answered that the programs have affected industry competitiveness negatively in the Santiago area (62%). Firms in noncompliance were more negative on this point.²²

We also inquired about the firms' views of the appropriate institutions. Most firms (86%) preferred to deal with one single governmental authority, rather than the split authority between CONAMA and SEREMI that now exists. However, we also learned that most firms wanted enforcement separated from appeal (68%). Currently, SEREMI issues and follows up on regulations in Chile and serves as a board of appeals. In other countries, there are separate boards (or courts) of appeal that deal with the resolution of conflicts between authorities and firms. This might be one feature that the Chilean authorities should consider developing.

Finally, 94% of our respondents would like more diligence, efficiency, and timeliness, when it comes to the trading procedure, which is reported to take between 3 and 12 months.

3.5. The relative importance of the shortcomings of the programs

It is not easy to say which failure has affected the performance of the trading programs to the greatest extent. However, when asked outright to ranking the elements that have negatively affected trading in Santiago, lack of information had the highest priority (42%), followed by the lack of diligence by the environmental authority (28%), and unclear rules (20%) that change all the time (8%). Indeed, 54% of the respondents who reported difficulties when trading stated that the main problem was the lack of clear information to accomplish the trading process.²³

It seems that the pitfalls in the implementation of the trading schemes have affected the attitude of the industry toward trading as such. Of our respondents, 58% said that it would be better if the environmental authority used a different policy to control emissions. Interestingly, national firms disliked trading permits the most.²⁴ Emissions standards (42%), technology regulations (40%), and emissions taxes (18%) were mentioned as substitute regulations.

²² Using a non-parametric test (Wilcoxon-Mann-Whitney test), the distribution of the attitudes toward the statement that permit programs affected industry competitiveness negatively in the Santiago area is shown to be significantly different between firms in violation and compliant firms ($p = 0.063$).

²³ Questions on the lack of clear information to accomplish the trading process were included in the questionnaire in three situations: 1) finding a trading partner without any public information, 2) understanding the rules behind the trading process, and 3) uncertainty regarding the approval of the transaction.

²⁴ Using a non-parametric test (Wilcoxon-Mann-Whitney test), the distribution of the attitudes toward the statement that it would be better if the environmental authority uses a different policy to control emissions, is shown to be significantly different between international and national firms ($p = 0.080$).

4. Reflections and conclusions for policy

We can draw some interesting conclusions from our in-depth study of the firms participating in the environmental trading programs in Chile. First, we want to highlight some positive findings. In sharp contrast to the general view that firms are reluctant to embrace environmental regulation, we found that firms in the Santiago programs did not have a generally negative attitude toward environmental regulations or environmental authorities. Furthermore, they did not seem reluctant to deal with environmental regulations; this was particularly true for firms with international ownership.

Interestingly, we also found that a large fraction of the firms demanded a stricter monitoring of sources in the trading programs. In old-fashioned regulation, it is unusual to find sources of pollution that ask for more frequent monitoring. We are tempted to say that this is likely to be the result of using a permit-based approach. When the regulations are transformed into pollution rights, they acquire some of the attributes of “property” and become valuable. Many sources realize that their permits are valuable—and in fact are more valuable if the monitoring and the whole system in general is more stringent. However, firms were dissatisfied with the implementation of the policies. This dissatisfaction seemed to correlate with lack of information about the policies and the lack of enforcement. Our findings allow us to offer a few clear policy recommendations. The most fundamental suggestion is that greater clarity is needed concerning the exact nature of the rights handed out and the exact penalties in case of noncompliance. Firms need to be able to predict the results of their actions with a minimum of time and cost and a maximum of accuracy. It is also very important to improve the flow of information to firms by enhancing public information about trading, such as historical records and forecasts. Finally, the authorities need to trust this new instrument and refrain from the discretionary power to modify details often and be involved in case-by-case tinkering with the system.

Also, because many firms stated that it was possible to escape penalties and that a significant fraction of the firms do not comply with the environmental regulations, disclosing information about compliance records could increase the credibility of the program and lead to standardization of the enforcement procedures. Transparency and expediency of the process creates pressure on the authorities to be consistent and even-handed and this builds credibility to the program and thus enhances the value of the permits.

Unclear regulations are not only unfortunate in themselves but they can provide opportunities for rent seeking by officials. Creating a simple and stable system of regulations and making enforcement transparent and evenly applied has the additional benefits of reducing transaction costs and risks of corruption. If this is not done, there is a risk that the permit trading is not taken seriously and the whole system degenerates back to a form of negotiated regulation wherein the authorities somehow have to regulate each source separately – which is neither fair nor efficient.

Even if only a small fraction of the firms in our study were reluctant to trade, due to the change in the offsetting rate (permits are depreciated progressively through trading), we strongly advise policymakers to avoid such rules because they create disincentives to trading in the long run. On the other hand, new technology is typically imbedded in capital creating a vintage structure in emission intensities so that old firms are much more polluting than new ones. Industrial turnover is on the whole positive from an environmental point of view, but will often be resisted since the status quo tends to mobilize more support than potential entrants. For the environment as well as for the economy, it is however preferable to

have a certain turnover with new firms being encouraged even partly at the expense of older ones. Changes in the rate of offsetting are therefore unfortunate since they might retard turnover of pollution sources, drive up the cost of environmental protection and increase pollution levels since they provide existing sources with perverse incentives to continue to operate while “taxing” newer and cleaner entrants.

Finally, we suggest some changes in the institutional setting. Even if most firms preferred a single environmental authority, we do not think that this is the reason underlying the current problems. Rather, the problem is that the two authorities (CONAMA and SEREMI) do not pursue the same objectives. While CONAMA is responsible for the design of the trading programs and is focused on environmental policy, SEREMI pursues many other objectives related to the health of the population in general. While we do not see a big problem with two authorities being responsible for different aspects of environmental emissions trading, we do believe that the authority in charge of enforcement should be autonomous and pursue this objective only. This also applies to the separation of enforcement and appeal. This is an important modification of the existing programs that the Chilean authorities should develop.

All in all, we conclude that the trading programs in Santiago, Chile, suffer from serious flaws in design and implementation. Rights need to be clarified and simplified, as do sanctions. Institutions need to become more efficient and transparent. On the other hand, these flaws are not necessarily more severe than some of the flaws in the recently designed European ETS system. One could point to the fact that it took the United States several decades of experimentation before they arrived at the current market design of their environmental trading programs. Chile has managed to establish environmental trading schemes in a relatively short time, during which they also developed the legal bases and institutions.

It is hard to judge what this implies for other countries, but it seems clear that countries with similar income levels and institutional maturity as Chile should be able to develop well-functioning permit trading schemes. This should apply to most of the middle-income or “emerging” countries of Latin America or Asia, as well as countries at comparable levels of development in Africa, such as South Africa. One should also remember that many of the other policy options to permit trading, such as taxation, also imply a need for sophisticated monitoring and institutions. It is not clear that trading schemes require significantly more “maturity,” nor is it certain that institutional maturity should be a definitive criterion when judging which countries can and should develop trading schemes. More practical experience is needed here.

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Appendix. Supplementary data

The supplementary data associated with this article can be found in the on-line version at [doi:10.1016/j.jenvman.2010.05.015](https://doi.org/10.1016/j.jenvman.2010.05.015).

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