Ecological modernization in Japan

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Ecological Modernization in Japan: The Role of Interest Rate Subsidies and Voluntary Pollution Control Agreements*

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Abstract

The need for developed countries to take a lead in the global fight against climate change is generally acknowledged and was intrinsic to the 2015 Paris climate change agreement. An understanding of the way in which environmental policy in advanced nations has developed and which policies have had a significant impact on the reduction in the emissions of various pollutants may yield important policy prescriptions relevant to the current climate change negotiations. In this paper we consider how Japan's little-known environmental interest rate policy and voluntary pollution control agreements contributed to Japan's ecological modernization and how these policies compare with the more traditional regulatory approach. Our results show that Japan's use of an environmental interest rate policy was an effective policy as a complement to the more traditional regulatory approach.

1. Introduction

A wide range of policies is now being used to reduce greenhouse gas emissions and reduce environmental degradation both locally and globally. The most prominent and well-known policies are taxes, quotas, and cap and trade mechanisms, which we might think of as sticks. What is often overlooked, however, is the considerable degree of support, which we can think of as the carrots, that governments provide to industries and firms to

help them reduce their environmental footprint and to encourage environmental innovation. Such support includes direct subsidies, reduced interest rate financing, regulation breaks, and price support. Despite the complexities associated with subsidies and their associated distortions, they continue to be part of the government toolkit, although more often than not governments have tended to resort to sticks when it comes to incentivizing firms to reduce their emissions of local and global pollutants.

In this paper we revisit the debate on how best to reduce industrial emissions by considering the example of Japan in the early 1970s when Japan made rapid progress on the reduction of pollution and quickly established itself as a country with one of the cleanest environments in the OECD (OECD 2000, 2002). Specifically, we examine the impact of two policies that were particular to Japan on its subsequent environmental performance. The first is Japan's policy of providing low interest rate financing to firms to invest in pollution abatement technologies. The second is the widespread use of voluntary pollution control agreements (PCAs) where firms sign a pollution reduction agreement with local government and local communities. Although much attention has been given to the effectiveness of environmental regulation and other "sticks" to reduce pollution, we ask whether Japan's environmental interest rate policy is the forgotten hero when it comes to explaining Japan's impressive environmental performance, or whether instead the distortions induced by these environmental subsidies have been responsible for additional pollution by aiding the continued survival of firms in Japan's traditional dirty industries. By analyzing the effectiveness of Japan's environmental interest rate policy we hope to provide insight into whether such a policy should be considered as part of the global policy armory against local and global pollutants.

The decades from the 1950s to the 1970s represent an ideal period to study Japan for two additional reasons. First, this was a period of rapid growth for Japan coupled with severe air and water pollution problems and pollution-related health damage.[1] Second, given that many other parts of the world, including China and India, are currently going through similar experiences of rapid industrialization and urbanization leading to significant negative pollution-induced externalities, there may be some important policy implications for those rapidly developing countries in Asia, Latin America, and Africa. A policy of growing first and cleaning up later risks significant damage to the long-term growth prospects of these regions, and of course to their environments as well. What is evident from the case of Japan during our period of study is that it is possible to address

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[1] The most widely cited example of pollution-related health damage is Minamata disease—a toxic disorder of the central nervous system caused by methyl mercury compounds from chemical factories contaminating fish in and around Minamata bay. The final death count was 1,542 (Ministry of the Environment 1997). Estimates of the costs of compensation are close to 100 billion yen paid annually for victims of pollution (Committee on Japan's Experience in the Battle against Air Pollution 1997, 45).

problems of pollution while continuing to grow rapidly. That is, it provides an example of how to ecologically modernize (Barrett 2005; Imura and Schreurs 2005).

Both of our environmental policies of interest—the policy of offering reduced interest rate financing for environmental investment and the use of PCAs—have been previously discussed in the environmental economics literature, although the majority of studies have tended to be descriptive in nature. Early studies examining the policy of lowering interest rates include Miyamoto (1989, 203–205) and Lee (1999). For a comprehensive review of the environmental policy in Japan see Imura and Schreurs (2005). Lee (1999) considers several interest rate subsidy schemes as part of the *zaito* system (Japanese fiscal system) and provides some descriptive evidence to show that interest rate subsidies did help to promote investment in abatement technologies.[2] Although similar to Lee (1999), we also provide a simple analysis to help clarify the effectiveness of Japan's policy of providing interest rate subsidies.

Turning to PCAs, which are voluntary agreements between the local government and businesses, a small number of studies have attempted to study their effectiveness (Gresser Fujikura, and Morishima 1981; Tsutsumi 2002). In a survey of PCAs, Matsuno (2007) concludes that PCAs vary across municipalities in terms of scale, quality, and enforcement and then finds that traditional industrial pollution problems were largely controlled by the use of PCAs and were shown to be most effective in the reduction of sulphur oxides.[3]

Before continuing, we briefly describe the theoretical and empirical literature that examines the impact of subsidies on the environment more broadly. The theoretical literature on the role of subsidies in an environmental context is limited and has tended to concentrate on input and output subsidies on intermediate inputs and exports, respectively, and not on subsidies to encourage environmental investment or innovation. For example, van Beers and van den Bergh (2001) use a static partial equilibrium model to show how emissions are increased with output subsidies in a small open economy. A second study by Kelly (2009) develops a general equilibrium model to show that the extent to which subsidies cause emissions to rise depends on relative emission intensities and the incentives to pollute for the subsidized industry versus the industry that would otherwise get the resources.

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2 Lee (1999) conducts one simple econometric analysis: (total abatement) $= \alpha$ (amount of lending) $+ \beta$ (tax deduction in abatement investment) $+ \gamma$ (interest rate gap subsidy) $+ \varepsilon$. He finds that lending is a significant and positive determinant of total abatement and that the interest rate gap is positive and weakly significant before 1980, although the effect of a simple tax deduction is insignificant.

3 Other studies of PCAs include Matsuno and Ueta (2002) and Noda (2015). A wider literature that examines the role of self-regulation and the impact on environmental performance (see, e.g., Arora and Cason 1995, 1996; Pargal and Wheeler 1996; Maxwell, Lyon, and Hackett 2000; Videras and Alberini 2000; Nakamura et al. 2001; Anton Deltas, and Khanna 2004).

The empirical literature on the effects of subsidies on environmentally sensitive industries is also limited and also tends to concentrate on those subsidies that are in place as part of industrial or competition policy and not as a means to improve the environment. As such, what evidence there is suggests that sectors such as agriculture, fishing and energy, manufacturing, transport, and water are all heavily subsidized (Barde and Honkatukia 2004). Barde and Honkatukia (2004) and Kelly (2009) go on to discuss the channels by which input and output subsidies affect the environment. The first channel is through tax relief, cash subsidies, or (more recently) bank bailouts—protecting the least efficient producers (which within a sector are likely to be the most pollution-intensive). Second, input and output subsidies in environmentally sensitive industries tend to encourage the overuse of dirty inputs, and third, regulatory relief increases the incentives for firms to pollute by lowering production costs. Finally, subsidies can be used in the traditional sense to protect domestic firms from competition. The possible distortions caused by these types of subsidies are why negotiations ahead of any new trade agreement tend to call for a reduction in subsidies paid to firms. For example, Bajona and Kelly (2012) estimate that China's removal of subsidies as part of the process of joining the WTO resulted in the reduction of three of the four pollutants that they studied.[4]

It is worth noting that, as with the manufacturing sector, subsidies can also have positive and negative effects in the agricultural sector (Pasour, Rucker, and Gardner 2005). In this case, subsidies to farmers may encourage, on the one hand, the additional use of fertilizers and pesticides, but on the other hand, may pay farmers to remove environmental sensitive areas from extensive farming.[5]

When discussing environmental policy in Japan it is important to remember that Japan was relatively late to industrialize and hence suffered significantly as a result of rapid industrialization made worse by a high population density and high levels of urbanization (which meant that residential areas were often situated close to industrial areas). It took a number of environmental scandals and protests against Japan's perceived weak environmental policy before anything changed (Imura and Schreurs 2005). As a consequence, both the government and industry were forced to change (law, management style, programs), resulting in Japan having one of the most advanced environmental programs in the world.[6]

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4 Other related studies for China include Wang and Jin (2007) and Wang et al. (2003), who find that China's state-owned enterprises are more polluting but also have more bargaining power over compliance respectively.

5 A related literature examines the impact of subsidised fossil fuels that are used to ensure that energy prices are kept low for both firms and consumers (Pitt 1983; Cheon, Urpelainen, and Lackner 2013; Burniaux and Chateau 2014). Both the World Bank and the IMF have recommended that such subsidies should be phased out over time (Durand-Lasserve et al. 2015).

6 Whereas we know that historically Japan's regulatory regime was successful in reducing emissions of local pollutants, similar strategies in China and elsewhere have not been considered as

To briefly summarize our results, we find that the use of an environmental interest rate policy did have a significant impact on reductions in abatement expenditure in Japan for one of our three lending institutions and that it appears to be more effective than the use of PCAs at the municipality level. Although the main driver of Japan's transition from polluter to one of the OECD's least-polluting countries per capita was direct regulation (as evidenced by the 1993 Basic Environmental Law), it is clear that the interest rate subsidy did result in considerable sums of money being funnelled into firms to use for environmental innovation and abatement investment, which significantly sped up the adoption and implementation of cleaner technologies. If such a policy were to have a similar effect in China or India it could result in significant reductions in both local and global pollutants, depending on which sectors were targeted. The recent introduction of a large number of green financing initiatives across the world shows that the global community has accepted that policies to encourage the adoption of green technologies have an important role to play alongside more traditional forms of environmental regulation.[7]

The remainder of the paper is organized as follows: Section 2 outlines the methodology and describes our data; Section 3 presents the results, and Section 4 concludes.

2. Methodology and data

We begin this section with a detailed discussion of our two policies of interest. Following a series of environmental disasters in the 1950s and 1960s, Japan has been at the forefront of environmental regulation. In the 1970s six new environmental laws were enacted and a further eight were tightened. The 1990s saw a further tightening of environmental legislation, and in 1993 Japan implemented what became known as the Basic Environment Law. In 1997 Japan hosted the UN Framework Convention on Climate Change, which resulted in the Kyoto Protocol and thrust international environmental issues to the forefront of Japan's industrial policy. In 2001 a Ministry of the Environment was established, incorporating the previous roles of the Environment Agency, taking environmental policy into the heart of government decision making. The culmination of these various policies is that Japan established one of the strongest frameworks for achieving a clean and healthy environment earlier than most OECD countries and demonstrated that a good environmental

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successful. The relatively poor performance is often blamed on a lack of effective enforcement, which is often a problem when the regulatory regime is mainly based on the use of sticks. See Economy (2004) for a discussion of the issue of enforcement in China.

7   An example of "green finance" includes pay-as-you-save, whereby loans to fund energy efficiency improvements are repaid from the resulting energy bill savings (and hence have little impact on government spending). Venture capitalists have also become increasingly interested in supporting green technology companies. Other examples include green investment banks, carbon finance, public–private partnerships, and tax increment financing. The recent financial crisis, however, has still left many firms unable to access the funds needed for investment.

reputation is not only good for the environment but is also a valuable economic and cultural asset (Sumikura 1998).[8]

Although the current environmental literature tends to concentrate on cap and trade, taxes, and command and control policies, a little-known method used in Japan in the early 1970s was the environmental interest rate differential. The aim of the environmental interest rate subsidy program was to encourage firms to invest in abatement technologies to reduce emissions. Abatement investment includes technology to reduce air pollution (such as desulphurization), water pollution, noise pollution, recycling, and industrial waste. A gap caused by arbitrarily setting lower interest rates for certain financial schemes than the current market rates can be considered as a subsidy for abatement investment. There were three main finance schemes for large firms in abatement investment. One scheme used finance programs by the Japan Development Bank (JDB), which is a government bank under the Ministry of Finance. The JDB had special lending programs in abatement investment, which offered lower interest rates than market rates. This program continued until 1999. The other scheme was conducted by the Japan Environmental Corporation (JEC) (*Kougai Boushi Jiigyoudan*) (1965–2003). JEC's lending programs for environmental projects ended in 1999. In contrast to the JDB scheme, the JEC money was targeted at not only large firms but also small- and medium-sized enterprises (SMEs). An example of this is the Japan Corporation for Small and Medium Enterprise (JASME) (*Chusho Kigyo Kinyu Koko*) (1953–2008), which was a government bank that specialized in helping SMEs. All three lending programs used the same strategy of lowering interest rates for investment in abatement technologies, although the level of discount against market rates differed by lending body (discussed further subsequently).

The policy initiative to use interest rates in this way required the Japanese government to establish a rate of interest on borrowing between the market rate and the *zaito* rate (the rate used for government public finance policy). Any funds borrowed at this cheap rate of interest were used to finance environmental projects with the aim of alleviating abatement costs and reducing pollution. The money could be borrowed by large firms from the JDB, the JEC, or local government bodies. Funding from the JDB ceased in 1999. Funding from the JEC also finished in 1999 (lending actually stopped in 1998). In part the policy was no longer possible because of Japan's zero interest rates from 1998 onward.

The subsidized environmental loan program started in 1960 when the JDB starting making loans for investment that would mitigate water pollution. In 1963 this was extended to loans to help reduce pollution of soot and smoke. Two years later the JEC also started a loan program for anti-pollution measures followed by the JDB in 1971. In that same

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8 See Appendix A for a history of environmental regulation in Japan.

year the Agency of Industrial Science and Technology set up a subsidy system. The main developments in what we could call environmental finance were as follows: In 1960 JDB started loans for investment against water pollution and then in 1963 it started a loan program for investment against soot and smoke. In 1965 JEC started its loan program for anti-pollution investment. In 1971 the JDB also implemented an anti-pollution investment loan program. This was matched in 1971 by the Agency of Industrial Science and Technology, which also set up a subsidy system for anti-pollution investment. Finally, in 1974 the Agency of Industrial Science and Technology directly subsidized environmental technology for NOx reductions.

We now turn to our PCA measure. Japan is a highly centralized country, the central government sets environmental standards and tends to have uniform regulations across the country. Environmental damages, however, are idiosyncratic across regions and some cities and villages need more stringent regulations. This led to a number of regional governments coming to voluntary agreements with local polluting firms, although the voluntary nature of any agreement means that they could not be legally enforced. The agreements tended to specify more stringent environmental regulations than the national laws and regulations and thus no legal penalty could be enforced as long as the national regulation levels were met. Thus, cities and environmental community groups were required to supervise the firm's behavior. One of the most famous examples is Yokohama city, which signed an agreement with Tokyo Denryoku (TEPCO) in 1965 and with Electric Power Development Co. Ltd. (*Dengen Kaihatsu*) in 1964.[9] Because firms want to give the impression of being "greener" and environmentally friendly, PCAs were popular with firms willing to accept these agreements in the 1970s and 1980s when public disquiet about the high levels of pollution were at their greatest and as a result so was the threat of even stricter government regulation.

In our data set the PCA variable is measured as the number of ratified pollution control municipal agreements signed during a given year (flow data) between a firm/plant and a local government body. We count the number of agreements in the manufacturing sector, the agricultural sector, and an overall total (including the energy sector). Figure 1 shows the number of agreements in the manufacturing sector. The contents of each agreement depend on the negotiating stance of each municipality and are taken from the Environmental White Paper by the Ministry of Environment Japan for each year from 1972 onwards and the Pollution White Paper for years before 1971. As Figure 1 clearly shows, the number of signed PCAs peaked around 1990 just before the 1993 Basic Law was enacted, and then fell away dramatically.

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9 This is known as a benchmark case, and is now called the Yokohama method (*Yokohama houshiki*). The oldest agreement was by the Shimane prefecture with Sanyo Pulp Co. Ltd. and with Daiwabo Co. Ltd. in 1952.

Figure 1. Number of PCAs in the manufacturing sector (1982–2002)
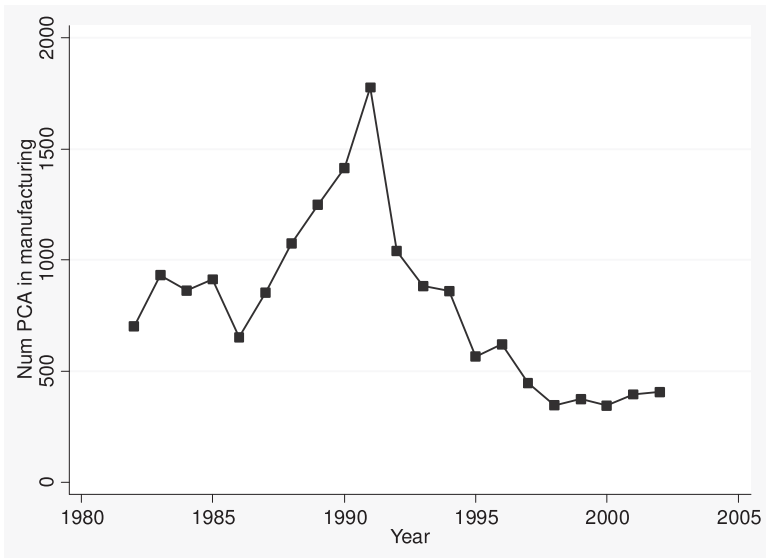
In terms of our other variables of interest, abatement expenditure is measured as the to-tal amount of abatement investment per firm taken from the Survey on Anti-pollution Investment (*Kougai Boushi Setsubi Toushi Chosa*), conducted by the Ministry of Economy, Trade, and Industry, Japan (METI). Per-firm abatement costs are measured by dividing total abatement investment by the number of firms that engage in abatement investment of some sort.

Interest rates and lending data for the JDB programs are taken from the JDB Annual Ac-tivity Report. The interest rate data are for those loans that were provided as part of the environmental-related investment program promoted by JDB. The JDB program ended in 1999 because of the reorganization of the Development Bank of Japan, which also has an environmental investment program (although it operated differently). After 1999 the environmental interest rates were set at the same level as the market interest rate and thus any benefit was removed by default. Our second interest rate variable is the rate set by the JEC programs taken from the JEC Annual Activity Report and is the interest rate that the JEC set for firms wishing to make environmental investments. The JEC was founded in 1965 and the program also finished in 1999. The JEC was reorganized in 2004 and became known as the Environmental Restoration and Conservation Agency. Finally, the inter-est rates and lending data for the JASME programs are taken from "Fifty Year History of

JASME." JASME (*Chusho Kigyo Kinyu Koko*) was founded in 1953 and specialized in SME lending for long-run investment. The JASME program finished in 2008.

These lending programs had slightly different targets. According to Lee (1999), JASME lending was mainly for SMEs; a main target in the JEC program was large companies, small business, local governments, and semi-public sectors; and the JDB program aimed at larger companies. Importantly, SMEs were more likely to face financial constraints and thus these lending programs were important as a means to encourage abatement expenditure.[10]

Each program consists of a number of sub-programs set up to lend money for specific purposes. These include investment not only in anti-pollution investment, but also energy-saving technology investment, waste disposal, relocation costs, and the maintenance of parks and greenbelts. Our main focus is on anti-pollution investment and thus we use abatement cost data only for anti-pollution investments of each program, although we also briefly consider the impact of energy-saving investment schemes.

Market interest rates and short-term prime lending rates are taken from the Historical Statistic of Japan (*Nihon Chouki Keizai Toukei*), Ministry of Internal Affairs and Communications. Unemployment rates and capital utilization (proxies for business cycle effects) are also taken from the Historical Statistic of Japan (*Nihon Chouki Keizai Toukei*), Ministry of Internal Affairs and Communications.

We include an environmental law dummy that takes a value of unity if the year is after 1993, which was when the Basic Environment Law was enforced. The Basic Environment Law includes not only pollution controls but also covers global environmental protection and international cooperation issues and is seen as a turning point in Japanese environmental policy. This partially explains the fall in PCAs following 1993. We also include data from the METI "Anti-pollution Investment Survey" in our sensitivity analysis. In terms of coverage, only large firms with more than 10 billion yen in capital were included. The survey has taken place every year since 1971. We combine data from this survey with standard macroeconomic variables for Japan from 1971–2005. The data are collected annually but is non-exhaustive.

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10 Each program had a slightly different scope and different lending conditions for a firm to qualify for abatement investment. See Lee (1999) for details. There might be some concern that the funds borrowed would not in fact be used for the purposes that the firm initially proposed. This possibility means that we need to be cautious in our policy prescriptions although as the policy is administered through bank lending rather than a direct policy usual bank lending policies would be in place to monitor how the funds were used. It is true, however, that some of the investment may have led to unsuccessful innovation that was subsequently scrapped and any environmental benefits lost.

Figure 2. Interest rates in Japan (1971–2005)
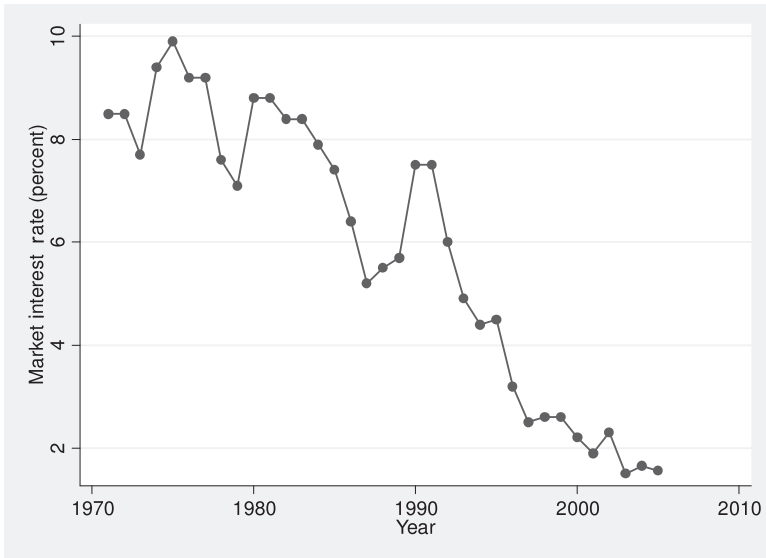
We now present the general trends in abatement costs and interest rate differentials for the time period in question. Figure 2 shows how interest rates have fallen dramatically over the past 35 years from a high of 10 percent in the early 1970s to close to zero by 2000. In those periods of high interest rates a policy of subsidized loans would be attractive to firms at that time that wanted to undertake environmental innovation.

Of course, the value of an environmental interest rate policy will be determined by the underlying market interest rate that is open to all firms for investment of any type. To estimate the effect of this policy on pollution, it is useful to consider the differential be-tween the market rate of interest and the rate offered by the JDB, the JEC, and JASME. The results are shown in Figure 3.

As shown, the gap between the market rate of interest and the subsidized rate fell dur-ing this period from a high of over 2 percent for JASME lending to close to zero on or around 2000 (although the JASME funding gap rose slightly in the early 2000s just before the scheme closed).[11] In Figure 4 we illustrate the amount of money lent by the three in-stitutions we consider in this paper. As can be seen, JDB lending was significantly higher

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11 The discrepancy for the JASME figures in Figures 2 and 3 is that JASME has a number of different schemes; the total lending refers to environmental lending whereas the interest rate gap that rose

Figure 3. The interest rate gaps for JDB, JEC, and JASME (1971–2005)
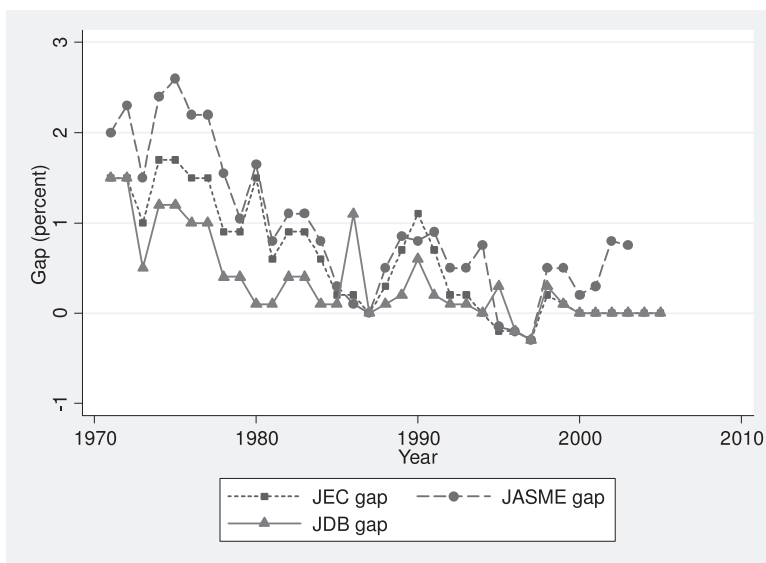
in absolute terms than the others with JASME lending being of a much smaller magnitude, no doubt as a result of a remit to lend to SMEs and not the large Japanese conglomerates. Again, we can see that the amount provided fell over time from the highs of the early 1970s.

Figure 5 presents a plot of the average abatement cost paid per firm per year and shows that the amount of money that firms had to pay for abatement expenditure fell dramatically from the highs of the early 1970s. This was a time when stringent regulations were introduced and marks the introduction of the environmental interest rate policy.

What we need to remember is that Japanese firms made large investments in the 1970s and 1980s as they shifted to energy-saving technologies following the oil price shocks in 1973 and again in 1979. Other regulations in Japan at this time also required the payment of abatement costs. After the 1990s, pollution had fallen considerably and many firms had already adopted cleaner technologies. Firms also had additional environmental concerns around recycling and the management of industrial waste. After the Kyoto Protocol in

after 2000 is for other schemes. After 2000 the overall size of the lending programs for JASME was reduced and simplified.

Figure 4.   Lending by institution (in million yen)
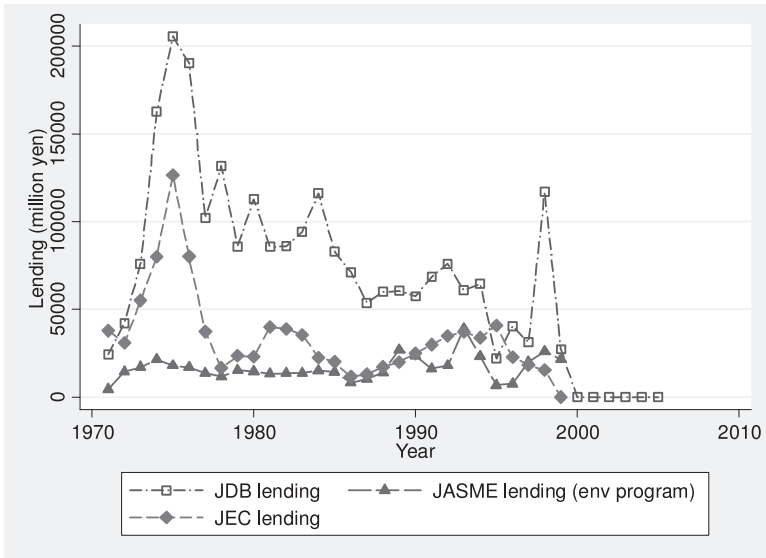
Figure 5.   Average abatement cost per firm (million yen in 1990 prices)
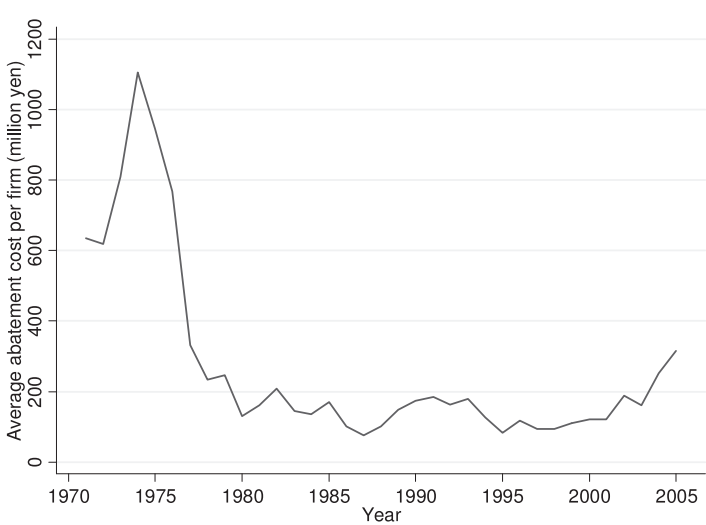
Table 1. Institutional lending and the interest rate gap

variable	(1) JDB lending	(2) JEC lending	(3) JASME lending (anti-pollution)	(4) JASME lending (energy-saving)
JDB interest rate gap	3.266** (1.196)			
JEC interest rate gap		0.801** (0.34)		
JASME interest rate gap			0.0252 (0.11)	2.763*** (0.843)
Constant	8.097*** (1.047)	9.556*** (0.416)	9.602*** (0.149)	8.267*** (0.626)
Observations	35	29	29	17
R^2	0.133	0.174	0.002	0.306

Note: Robust standard errors in parentheses. *** Statistically significant at the 1 percent level **statistically significant at the 5 percent level; *statistically significant at the 10 percent level.

1997 (ratified in 2005), the global warming agenda related to carbon dioxide emissions and greenhouse gases was given prominence over concerns of local pollution levels.

We now turn to our econometric analysis, which consists of a number of simple ordinary least squares regressions with robust standard errors that covers our 30-year period. All variables are in logs except for the interest rate gap, share variables, and our basic environmental law dummy variable. In a series of estimations we examine the role of interest rate subsidies and PCA agreements on total abatement expenditure and abatement expenditure per firm. We also control for a range of variables that are thought to influence firm investment, including the unemployment rate, capital utilization, and a measure of Tobin's q (to capture macroeconomic cycle effects).

In the first instance we do a quick check to see whether the banking system was working correctly to the extent that firms borrow more when the interest rate gap increases. The next stage is to examine whether the government-set rate of interest affects lending and so we estimate the level of lending by institutions against the interest rate and the interest rate gap. We then run a series of estimations examining the relationship between abatement expenditure per firm and total expenditure and our environmental policy variables. Finally, we estimate whether abatement investment contributes to reduced emissions. Using two-stage least squares (2SLS) estimations, decreases in carbon monoxide, Nitrogen monoxide, nitrogen dioxide, sulfur dioxide, and ocean pollution are regressed against total abatement expenditure, which is determined by lending and a number of macroeconomic variables. Table B.1 of Appendix B provides a detailed description of the data. Table B.2 provides some basic summary statistics.

3. Results

The first estimations investigate the relationship between the government rate of interest and total lending. The left-hand side of Table 1 is the log of the amount each institution

Table 2. Impact of interest rate gap on abatement expenditure per firm (1970–2005)

Variable	(1) Model 1	(2) Model 2	(3) Model 3
JDB interest rate gap	0.284 (0.188)		
JEC interest rate gap		0.145 (0.211)	
JASME interest rate gap			0.256* (0.127)
Capital utilization	0.0167** (0.00696)	0.0138* (0.00741)	0.0203** (0.00763)
Env law	0.773*** (0.168)	0.764*** (0.212)	0.700*** (0.204)
Interest rate	0.122** (0.0453)	0.0967* (0.0528)	0.0794* (0.0441)
Unemployment	−0.216*** (0.0643)	−0.245*** (0.0835)	−0.234*** (0.0799)
Constant	4.030*** (0.719)	4.501*** (0.688)	3.867*** (0.700)
Observations	35	35	33
R^2	0.535	0.494	0.538

Note: Robust standard errors in parentheses. *** Statistically significant at the 1 percent level ** statistically significant at the 5 percent level; * statistically significant at the 10 percent level.

lent to firms for each type of environmental investment. The right-hand side includes a measure of the interest rate gap. Not surprisingly, we find that the larger the gap (the effective subsidy for environmental investment) the larger the amount lent to firms, although this does not appear to hold for the JASME interest rate gap—suggesting that SMEs are less price-sensitive. Although our main focus is abatement expenditure, column 4 reports the results for energy-saving investment as a result of the JASME lending program. Note that the program for saving energy is more recent (since 1978) and hence the sample size is much smaller.

In the next stage we investigate the determinants of firm-level abatement expenditure. As seen in Table 2, only the JASME interest rate gap has a significant impact on firm-level abatement expenditure. The greater the difference between the central rate of interest and the subsidized rate of interest, the more additional abatement investment was made by firms (in this case SMEs following JASME funding). In terms of the other controls, we find that capital utilization is a positive and significant determinant of abatement expenditure, suggesting that more is invested in the boom times of the business cycle. Similarly, the unemployment rate is a negative determinant of abatement expenditure, with a similar business cycle interpretation. As expected, our environmental law dummy for the years after 1993 is a positive and significant determinant of firm-level abatement expenditure. We also find that the market interest rate is a positive determinant of investment.[12]

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12 As part of our robustness checks we also included a measure of Tobin's q (the ratio between a physical asset's market value and its replacement value) from Piketty and Zucman (2013) as a

Table 3. Total abatement investment expenditure and institutional lending (1970–2005)

Variable	(1) Model 1	(2) Model 2	(3) Model 3	(4) Model 4	(5) Model 5
JDB lending	0.0596**			0.280*	0.181
	(0.0241)			(0.158)	(0.111)
JEC lending		0.212**		0.118	0.148*
		(0.102)		(0.115)	(0.0823)
JASME lending			0.175	0.0156	0.0404
			(0.175)	(0.159)	(0.101)
Capital utilization	−0.00976	−0.0140**	−0.0110	−0.0106	
	(0.00631)	(0.00620)	(0.00723)	(0.00744)	
Env law	0.371**	0.199	0.355**	0.462*	
	(0.136)	(0.166)	(0.169)	(0.223)	
Unemployment rate	−0.148	0.149	−0.194*	−0.0398	
	(0.101)	(0.209)	(0.109)	(0.281)	
Constant	13.28***	11.47***	12.48***	9.250***	8.918***
	(0.624)	(1.351)	(1.638)	(1.996)	(1.592)
Observations	35	29	29	29	29
R²	0.608	0.501	0.333	0.614	0.444

*Note: Robust standard errors in parentheses. ***Statistically significant at the 1 percent level*
***statistically significant at the 5 percent level; *statistically significant at the 10 percent level.*

In Table 3 we examine the impact of total lending from the three institutions on the total abatement expenditure of firms where we also control for the interest rate, unemployment rate, capital utilization, and our environmental law variable. Our results show that total abatement expenditure is influenced by the 1993 Basic Environmental Law and to some extent the amount of lending by our two of our three institutions. Again, JASME is insignificant, which is perhaps not surprising given the small amount of money loaned to firms (as shown in Figure 3). Both JDB and JEC lending resulted in more abatement expenditure. This suggests that polluting firms spent more on abatement but also borrowed more money, presumably to spend reducing future pollution.

We now examine the impact of our PCAs or voluntary agreements on abatement expenditure (Table 4). Again, the left side is abatement expenditure per firm. On the right side we include the number of voluntary agreements as well as our other control variables including the number of complaints about pollution to the city offices and government and the number of environmental laws enacted. Our results show that our PCA agreement variable (whether total or broken down by agriculture or manufacturing) is insignificant. The main variables of significance in these estimations are the 1993 Basic Environmental Law dummy and the unemployment rate.

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measure of investment environment at the country level. Where significant, our Tobin's q variable is negative, suggesting that abatement investment behaves differently to the more usual capital investment. The other results are quantitatively and qualitatively similar. Results are available upon request. At the firm level, Tobin's q is included as a measure of financial performance, but few studies find a causal relationship between emissions and financial performance.

Table 4. Abatement expenditure per firm and PCA (1970–98)

Variable	(1) Model 1	(2) Model 2	(3) Model 3
PCA total agreements		0.108	−0.00977
		(0.218)	(0.387)
PCA manufacturing	0.140		
	(0.228)		
PCA agriculture	−0.0146		
	(0.151)		
Unemployment	−0.256***	−0.267***	−0.370
	(0.0638)	(0.0589)	(0.343)
Capital utilization	0.000476	0.00103	−0.00743
	(0.0204)	(0.0191)	(0.0533)
Env law	0.791**	0.784**	0.895**
	(0.354)	(0.338)	(0.344)
Interest rate	0.0634	0.0613	0.0661
	(0.0635)	(0.0514)	(0.0667)
Claims			0.115
			(1.061)
Env_law_number			0.371
			(2.425)
Env gov budget share			−0.217
			(0.738)
Constant	5.136***	5.248***	5.001
	(1.450)	(1.462)	(11.59)
Observations	21	21	21
R^2	0.680	0.677	0.687

Note: Robust standard errors in parentheses. ***Statistically significant at the 1 percent level **statistically significant at the 5 percent level; *statistically significant at the 10 percent level.

In Table 5 we examine the effect of PCAs on total abatement cost expenditure. The coefficients on our PCA variables are rather inconsistent and generally insignificant. Again, our environmental regulation dummy is a positive and significant determinant of total abatement expenditure. Our other controls are broadly similar. The number of regulations and the number of claims to local government are all insignificant determinants of total abatement investment.

As part of our sensitivity checks we also undertook a series of robustness checks including using pollution variables instead of abatement expenditure and the results were broadly similar.

Overall, PCAs have a weak impact on total and per-firm abatement expenditure. We can interpret this in two ways. First, although some specific cases such as Yokohama city were considered to be successful (as shown by previous studies), PCAs overall do not appear to have had a significant impact. Second, our PCA variables might be not perfectly measured as we only count the number of PCAs and do not take into account the size and scope of the PCAs.

Finally, Table 6 reports the impact of total abatement expenditure on air and ocean pollution. Because, as mentioned earlier, abatement expenditure is endogenous, we utilize

Table 5. Total abatement investment and PCAs (1970–98)

Variable	(1) Model 1	(2) Model 1	(3) Model 3	(4) Model 4	(5) Model 5
PCA total agreements		0.226*		−0.236	−0.219
		(0.111)		(0.148)	(0.209)
PCA manufacturing	0.384*		−0.109		
	(0.208)		(0.121)		
PCA agriculture	−0.178		−0.189**		
	(0.162)		(0.0820)		
Unemployment			−0.426***	−0.454***	−0.510***
			(0.0376)	(0.0433)	(0.148)
Capital utilization			−0.0308***	−0.0294***	−0.0533**
			(0.00820)	(0.00754)	(0.0205)
Env law			0.776***	0.779***	0.763***
			(0.128)	(0.131)	(0.150)
Interest rate			0.0579**	0.0327	0.0402
			(0.0230)	(0.0231)	(0.0235)
Claims					−0.590
					(0.475)
Env_law_number					1.449
					(1.044)
Env gov budget share					0.0297
					(0.309)
Constant	10.90***	11.10***	17.92***	17.99***	22.58***
	(0.841)	(0.760)	(0.728)	(0.875)	(5.133)
Observations	21	21	21	21	21
R-squared	0.212	0.140	0.898	0.868	0.907

*Note: Robust standard errors in parentheses. *** Statistically significant at the 1 percent level ** statistically significant at the 5 percent level; * statistically significant at the 10 percent level.*

Table 6. Impact of abatement expenditure on emissions

Variable	(1) Nitric oxide	(2) Nitrogen dioxide	(3) Sulfur dioxide	(4) Carbon monoxide	(5) Ocean pollution
Abatement costs	−0.001**	−0.002**	−0.001***	−0.196***	−0.093**
	(0.001)	(0.001)	(0.001)	(0.069)	(0.042)
Constant	0.024**	0.03**	0.022***	2.45335***	1.17**
	(0.011)	(0.012)	(0.008)	(0.868)	(0.526)
Observations	29	29	29	29	29

*Note: Robust standard errors in parentheses. *** Statistically significant at the 1 percent level ** statistically significant at the 5 percent level; * statistically significant at the 10 percent level.*

2SLS and use Model 4 in Table 3 as the first stage. In the second stage, the change in emission levels from t–1 to t is regressed on total abatement expenditure at t–1. The coefficients on abatement expenditure are all negative and significant, suggesting that as abatement expenditure increases, emissions are reduced.

4. Conclusion

In this paper we examined various aspects of Japanese environmental policy. Although our results show that the implementation of the Basic Environmental Law in 1993 was important in reducing Japan's high emissions levels, we also find that Japan's innovative strategy of having interest rate subsidies for firms wanting to borrow to invest in

clean technologies also had a small but positive effect on firms' ability to reduce pollution. Hence, Japan's interest rate policy appeared to work in that the larger the interest rate gap, the larger the abatement investment (although this was only significant for lending to SMEs from JASME). This result is despite the relatively low interest rate gap, which fell further as Japan entered a long period of low interest rates from the financial crash at the end of the 1980s. A note of caution is that, although the lending was carefully monitored by the lending institution, it is possible that suboptimal investment took place or that the abatement technologies were later scrapped and any environmental benefits were lost.

When we examined the impact of PCAs, our results showed no evidence that the use of PCAs had any effect on firm expenditure on pollution abatements. This might reflect the nature of the agreement, which might be to limit emissions to current levels or to agree not to increase emissions beyond certain limits. These agreements were also only signed with a small number of large firms, so the aggregate impact may well have been masked when we consider large numbers of firms.

Although our results show that using a type of green financing such as interest rate reductions for abatement investment can be an effective environmental policy, they might not be directly applicable to the current environmental concerns faced by China and India. In the time since our period of analysis the world has seen considerable growth in global supply chains and the fragmentation of production. This means individual multinational corporations may be more sensitive to government regulation and move production to low-regulation countries (a pollution haven effect). Hence, the use of stringent environmental policy could have a detrimental impact on local employment and competitiveness. This suggests that the use of carrots, such as an environmental interest rate policy or other green deal financing options, might be a more business-friendly solution to both local and global pollution problems even though the low interest rate environment experienced by many countries will limit the effectiveness of such policies.[13]

There are other reasons why our results need to be treated with caution when considering solutions to the current global environmental problems. First, since the 1970s there have been dramatic improvements in technology (and environmental technology), which means that abatement investment may be cheaper and more effective at least in certain heavy industrial sectors (a technique effect). Nevertheless, the scale of growth in many

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13 In the current globalized world, pollution havens have been found in Asia, in which pollution intensive production locates in countries with lax environmental regulations. See, for example, Cole, Elliott, and Okubo (2010). Waste havens have also been found, where industrial waste is exported to China without recycling (Okubo, Watabe, and Furuyama 2016). However, also for Asia, Ramstetter et al. (2013) find that for Thailand, Malaysia, and Indonesia, foreign MNEs were not statistically more energy efficient than domestic firms suggesting that attracting multinational enterprises should not be driven by a desire to improve overall energy efficiency.

industrializing countries means that demand for energy and consumption goods is likely to continue to outweigh any technique effect. Second, as we saw in Paris in 2015, there is a strong move toward establishing workable global environmental agreements to tackle climate change, which will have abatement investment at the heart of the solution. Finally, we are in a world of environmentally aware global consumers, especially in the West, who demand environmentally friendly goods and products. This means that stringent regulations are not required as firms will increasingly use self-regulation when it becomes apparent that being green sells. Overall, it could be argued that the trade-off between economic growth and environment is not as severe as that faced by Japan in the 1970s.

In future research we want to look more closely at the firm-level determinants of abatement expenditure to examine how firm size, ownership, global engagement (importing and exporting), and access to finance affect a firm's decision to investment in abatement technologies. The relationship between access to credit and environmental investments is an important area of research as governments around the world attempt to meet increasingly stringent emissions targets, especially in the area of carbon dioxide and other greenhouse gas emissions.

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Appendix A: History of Japanese Environmental Policy

These tables are an extension of Lee (1999, Table 2, p. 34).

Table A.1 Regulations and laws

1962	Smoke and Soot Regulation Law (–1968)
1967	Basic Law for Environmental Pollution –1993)
1968	Air Pollution Control Law (SOx K-value Regulation)
	Noise Regulation Law
1970	Water Pollution Control Law
	Waste Disposal and Public Cleansing Law
1971	Environmental Agency
	Toxic metal regulations (BOD, COD, SS)
	SOx K-value Regulation (third revision)
	Offensive Odor Control Law
1972	SOx K-value Regulation (fourth revision)
	The Nature Conservation Law
1973	Law Concerning Pollution-related Health Damage Compensation and other Measures
1974	SOx Total Pollutant Load Control
1975	NOx density regulation (second revision)
1977	NOx density regulation (third revision)
1978	Total Pollutant Load Control (water pollution)

Table A.1 Continued.

1979	Law Regarding the Rationalization of Energy Use
1981	NOx Total Pollutant Load Control
1988	Law Concerning the Protection of the Ozone Layer through the Control of Specified Substances and Other Measures
1989	Montreal Protocol on Substances that Deplete the Ozone Layer
1990	Environmental Labelling System (Eco-mark)
1992	Framework Convention on Climate Change (sign in 1992 and ratify in 1993)
	Law Concerning Special Measures for Total Emission Reduction of Nitrogen Oxides and Particulate Matter from Automobiles
1993	Basic Environment Law
1994	Basic Environment Plan
1997	Kyoto Protocol (COP3)
	Environment Impact Assessment Law
1998	Law for Recycling of Specified Kinds of Home Appliances
1999	Law Concerning Special Measures against Dioxins
2000	Basic Law for Establishing the Recycling-based Society
2001	Total Pollutant Load Control (fifth revision)
	Ministry of Environment was formed from the sub-cabinet level
2003	Basic Plan for Establishing the Recycling-based Society

Source: Lee (1999).

Note: BOD = biochemical oxygen demand; COD = chemical oxygen demand; NOx = nitrogen oxides; SOx = sulphur oxides; SS = suspended solids.

Table A.2 Main diseases related to pollution

1955	Itai-itai disease
1956	Minamata disease
1965	Niigata Minamata disease
1960–1972	Yokkaichi asthma

Source: Lee (1999).

Appendix B: Data

Table B.1 Variable definitions and data sources

Variable	Definition/Source
PCA total agreements, PCA manufacturing, PCA agriculture	The number of ratified pollution control agreements coming into force during the year (flow data). The number of agreements ratified between a firm/plant and the local regulatory body. Agreements on pollution control between local governments and firms. We count the number by manufacturing sector firms excluding agreements in the agriculture, electricity and energy sectors. The content of any agreement depends on the situation in each location and are thus more flexible than governmental regulations and environmental laws. Source: "Environmental White Paper", the Ministry of Environment Japan, each year from 1972 and the "Pollution White Paper" before 1971.
JDB interest (percent)	Measures the interest rate for loans as part of the environmental related investment program promoted by the JDB. Source: Annual Activity Report, JDB.
JEC interest (percent)	Measures the JEC interest rate for loans related to environmental investment. Source: Annual Activity Report, JEC
JASME interest (percent)	Measures the JASME (1953–2008) interest rate for loans for environmental investment. Source: "Fifty Year History of JASME", JASME.
JDB interest rate gap JEC interest rate gap JASME interest rate gap	Measures the gap between the JDB (JEC, JASME) interest rate and the equivalent market interest rate. Market interest rates are recorded as the short-term prime lending rate. Source: The Historical Statistics of Japan Ministry of Internal Affairs and Communications.

Table B.1 Continued.

Variable	Definition/Source
JDB lending JEC lending	Total amount of loans by JDB (JEC, JASME) for environmental investment (unit: million yen).
JASME lending (anti-pollution) (saving-energy)	"Fifty Year History of JASME"; Annual Activity Report, JDB; Annual Activity Report, JEC.
Abatement costs per firm	Abatement costs per firm. This is average abatement costs (total abatement costs divided by the number of firms which spend anti-pollution investment). Source: "Survey on Anti-pollution Investment", Ministry of Economy, Trade and Industry, Japan.
Abatement costs	Total abatement costs (macro-level abatement costs). Source: "Survey on Anti-pollution Investment", Ministry of Economy, Trade and Industry, Japan.
Env gov budget share (from 0 to 1)	Measures the portion of environmental conservation expenditure in the national budget. Environmental conservation expenditure is divided by the national budget.
Env Law	Dummy after enforcement of the Basic Environment Law (1993).
Claims	Number of claims on pollution to city offices and government. Source: Historical Statistic of Japan, Ministry of Internal Affairs and Communications, Japan.
Capital utilization	Operation ratio. If a firm operates at 100 percent the index is given a value of 100. Source: Historical Statistic of Japan, Ministry of Internal Affairs and Communications, Japan.
Unemployment rate (percent)	Unemployment rate. Source: Historical Statistic of Japan, Ministry of Internal Affairs and Communications, Japan
Interest rate	Market interest rate. Long-run prime interest rate.
Env_law_number	Number of anti-pollution laws and regulations.
CO, NO1, NO2, SO2	Air pollution (ppm). Source: Historical Statistic of Japan, Ministry of Internal Affairs and Communications, Japan.
Oceanpollution	The number of confirmed cases of sea pollution. Source: Historical Statistic of Japan, Ministry of Internal Affairs and Communications, Japan.

Table B.2 Summary statistics

	Mean	Std	Min	Max
Abatement per firm	5.778527	0.375924	5.145427	6.611792
Abatement total	12.68904	0.458674	11.67776	13.77937
JDB interest rate gap	0.357143	0.480371	−0.3	1.5
JEC interest rate gap	0.568571	0.626274	−0.3	1.7
JASME interest rate gap	0.934849	0.798386	−0.3	2.6
JDB lending	9.262965	4.306151	0	12.23304
JEC lending	10.10584	1.203566	4.532599	11.74798
JASME lending (anti-pollution)	9.626878	0.446608	8.402679	10.57839
JASME lending (saving energy)	9.478218	2.099488	6.122493	11.63051
PCA manufacturing	6.751969	0.47264	6.040255	7.590347
Env govt budget share	1.239714	0.225864	0.68	1.64
Env law	0.371429	0.490241	0	1
SO2	0.008371	0.005688	0.004	0.027
NO1	0.0128857	0.005875	0.008	0.041
NO2	0.018029	0.005549	0.014	0.044
CO	0.8971429	0.5798	0.4	2.7
Claims	11.22746	0.141696	11.02458	11.51615
Ocean pollution	6.894057	0.4928801	6.052089	7.807917
Env law number	2.934897	0.393889	1.386294	3.218876
PCA agriculture	103.0476	68.02094	30	357
Capital utilization	87.48	13.52222	55.5	102
Unemployment rate	2.871429	1.192272	1.2	5.4

Note: All variables are in logs except dummy, ratio, and share variables.