Possible impacts of environmental taxes, subsidies and emissions trading on the foundry industry: a domestic and global analysis

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Possible impacts of environmental taxes, subsidies and emissions trading on the foundry industry, a supporting industry for the machinery industry (e.g., automobile) : a domestic and global analysis

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Abstract

To create a more practical model for comparing the long-run impact of environmental taxes and subsidies on an industry using partial equilibrium analysis, this paper examines the long-run impact of (1) a CO_2 tax, (2) subsidies for CO_2 emissions reduction (e.g., favourable tax treatment for investment in equipment with advanced technology that can reduce real CO_2 emissions) and (3) CO_2 emissions trading on the foundry industry, which is a supporting industry for the machinery industry (e.g,, automobile) both domestically and globally. Energy intensity is considered as a key parameter indicating the state of energy conservation technology for equipment. The model was used to estimate the possibilities of (1) analysing the above 3 measures within the same framework, (2) a serious impact on the Japanese foundry industry by the CO_2 tax, (3) global and local reductions in industrial CO_2 emissions by a subsidy, (4) serious difficulties in the implementation of emissions trading, (5) CO_2 emissions trading having basically the same impact as the tax or subsidy, (6) increases in global industrial CO_2 emissions by a tax introduced in industrialised countries only.

1. Introduction

Hanley, Shogren and White (2007, pp. 100) and Lee (2004) reported that environmental subsidies are found in many countries. However, as noted by Niizawa (1997), few articles have been written on this subject, although Baumol and Oats (1998, Ch. 14) and Hanley, Shogren and White (2007, Ch. 4) have compared the impact of environmental taxes and subsidies on an industry in the long run using partial equilibrium analysis. In the present study, I attempt to: (1) modify the model and analysis presented by Baumol and Oats (1998, Ch. 14) and Hanley, Shogren and White (2007, Ch. 4) for more practical application; (2) focus on global climate change perspectives; (3) simplify the existing model, especially concerning equipment technology deployment, which seems to be critically important; (4) include emissions trading in the model; (5) apply the model to a specific industry (i.e., the foundry industry[1], a supporting industry for the machinery industry), in which I have experience as a policymaker at the Ministry of Economy, Trade and Industry (METI) of the Japanese government[2]; (5) analyse the possible impact of policy differences among countries.

[1]Another name for this industry is the casting industry.
[2]I was in charge of the Japanese foundry industry from February 1987 to October 1988, at which time METI was known as the Ministry of International Trade and Industry (MITI).

The aim of this study is to analyse the possible impact of environmental taxes, subsidies and emissions trading on the foundry industry in the long run, both domestically and globally, using partial equilibrium analysis. Before explaining the model, an overview of the foundry industry in Japan is provided in the next section.

2. Overview of the foundry industry in Japan[3]

The foundry industry, a supporting industry for the machinery industry, is a parts (e.g., automobile engines) provider positioned between upstream (steel, coke) and downstream (automobile, machine tool) industries. The foundry industry consists primarily of numerous small-sized enterprises (1,054 establishments in 2005), most of which are subcontractors. For example, in 2005, about 70% of foundry production was from establishments with less than 100 employees, and more than 90% of foundry establishments had less than 100 employees. A significant feature of this industry is its low profit ratio. For example, in 2004, the ratio of operating profit to sales for the foundry industry was 3.2%, which was much lower than manufacturing average of 6.2%, the steel average of 13.2%, or the automobile industry average of 5.1%. Due to its low profit ratio and lack of funds, technological development and equipment investment in the foundry industry tends to be delayed[4], despite the fact that it belongs to the process industry, where equipment (i.e., foundry machinery) plays a critical role. Another important feature of this industry is its high energy intensity[5].

3. Model and analysis of possible domestic and global impacts of environmental taxes, subsidies and emissions trading on the foundry industry

3.1 Defining the model

Since this paper focuses on global climate change, externalities refer to carbon dioxide (CO_2) emissions. Long-run analysis was chosen because it is generally considered more important than short-run. The reasons for partial equilibrium analysis include: (1) its

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[3] The information in this section is taken from METI (2006)(a), METI (2006)(b), the Japan Foundry Association (2006) and the Japan Foundry Machinery Manufacturers' Association (2006). Although my experience in the industry took place about 20 years ago, many key features seem to be unchanged.

[4] To be more precise, disparity among firms in this industry has been increasing. As noted by Hashimoto (2008), strong firms have been able to invest in equipment, while weak firms have difficulty in doing so.

[5] Energy intensity means energy consumption per unit of production.

simplicity and clarity; (2) the small size of the foundry product market[6]; (3) the fact that the prices of other goods (e.g., automobiles) tend not to be influenced by changes in the foundry product market, not only because the industry is small but also because its related industries (e.g., automobiles and steel) are much more powerful than the foundry industry itself. Competitive industry is assumed because: (1) there are a large number of firms, as noted in Sec. 2; (2) the firms appear to be price takers, at least partially, because of the power structure stated above; (3) entry and exit seem to be relatively free; and (4) product differentiation appears to be difficult (i.e., if product differentiation was easy, foundry firms would have a low likelihood of suffering from low profit).

3.2 Type of measures considered

The type of environmental tax considered is a CO_2 tax, as a real environmental tax proposed by the Japanese Ministry of the Environment (MOE)[7] which is also consistent with the focus of global climate change, as stated in Sec. 3.1.

This type of environmental subsidy is a payment to a firm based on its CO_2 emissions reductions from base emissions. A typical existing subsidy for the foundry industry is favourable tax treatment for investment in equipment (e.g., foundry machinery) with advanced technology which can reduce CO_2 emissions[8] by energy conservation. For example, if a firm buys a designated foundry machine which costs 4 million yen[9] (about 40,000 US dollars), it is entitled to either a tax reduction of 280,000 yen (about 3,000 US dollars) or a special depreciation of 1.2 million yen (about 12,000 US dollars). This can be translated as either a 7% tax reduction or a 30% special depreciation for an equipment investment cost, as stated in the Energy Conservation Center, Japan (ECCJ) (2008). I tend to think that payments to a firm based on CO_2 emission reductions from base emissions may be used as approximation of the above typical existing subsidy, because utilising this subsidy would bring about increased

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[6] Mas-Colell, Whinston and Green (1995) reported that a small product market comparing with the whole economy can be illustrated by partial analysis.

[7] The MOE (2005) defines environmental taxes as CO_2 tax. Although the specific framework of the MOE is taxes on fossil fuel usage based on carbon contents, for simplicity, the CO_2 tax was used as an approximation of these taxes in the present model. Additionally, although the MOE has not specifically mentioned taxation of the foundry industry, such taxation cannot be ruled out in the long run.

[8] The Japan Foundry Machinery Manufacturers' Association (2006, pp. 16) proposes a 20% CO_2 emission reductions in the future by introducing foundry machinery with advanced energy conservation technology.

[9] METI (2006)(b), pp. 188) gives the average price of a foundry machine as 3 million yen (about 30,000 US dollars); a designated machine with advanced technology is likely to be more expensive.

investment in designated foundry machinery with advanced technology, and thus increased CO_2 emissions reductions.[10]

The type of emissions trading considered is allocation to the foundry industry, which is a downstream allocation[11]. Free allocation, which is either the benchmark (allocation based on industry-specific emission intensity) or grandfathering (allocation based on past emissions record) methods, is considered; these methods are also utilized by the MOE (2008, pp. 9). Auction is not considered, because it would impose an excessive cost burden[12] on the foundry industry, which consists mainly of small-sized firms and already suffers from a low profit ratio. One of the serious difficulties expected in the implementation of emissions trading is the difficulty in allocating allowances fairly, for several reasons[13]. Under the benchmark method, weak firms (see Note 4) would be unable to comply, due to a large apparent difference between the benchmark intensity and their current intensity, while strong firms could easily achieve the benchmark and then sell emission allowances. Under the grandfathering method, however, weak firms could comply because such firms have already been operating inefficiently due a delay in technological equipment investment. Additionally, because of expected compliance, which could bring additional revenue from the sale of allowances, funds for introducing equipment with advanced emissions-reducing technology might be easier to obtain for weaker firms, while the past emissions reduction efforts of strong firms may go unacknowledged. Another expected serious difficulty would be the cost of implementation, which could be substantial due to the number of enterprises comprising the foundry industry[14], although industry associations and/or cooperative societies, especially at the regional level, could contribute to solving this problem. It could be argued that small-sized enterprises can be excluded from emissions trading.However, since about 70% of production comes from establishments with less than 100 employees, and since over 90% of establishments have less than 100 employees, this would exclude the vast majority of the industry. As a result, emissions

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10 According to Kishimoto (1998), when an emission reduction is in proportion to investment in equipment, a favourable tax treatment on investment can be regarded as approximation of subsidies for emission reduction.

11 Here, downstream means downstream of energy flow, i.e., the final consumption stage, which is different from the definition given in Sec. 2. All of the industries mentioned in Sec. 2 are downstream. The MOE (2008, pp. 12) suggests that upstream allocation may in fact result in lower motivation to reduce emissions.

12 MOE (2008, pp. 9).

13 Hashimoto (2008).

14 While the MOE (2008, pp. 14) might not be currently considering allocation to the foundry industry in its Option 2 (Downstream Allocation) (End-Use of Electricity), the possibility of its introduction in the long run cannot be ruled out.

trading would likely be ineffective.

3.3 Basic framework

The relationship between output, energy intensity, emission coefficient and CO_2 emissions can be written as follows.

$$s = cgq \quad (1)$$
[15]

where s = CO_2 emissions

c = CO_2 emission coefficient

g = energy intensity

q = output of foundry product

For simplicity, no fuel switching (e.g., from coal to gas) is assumed. Therefore, the emissions coefficient would be the same in each case stated below. As a result, energy intensity, which could indicate energy conservation[16] technology for equipment, plays a critical role in the analysis.

Assuming that a profit-maximizing firm belonging to the foundry industry is subject to a fixed CO_2 tax per unit of emissions, its profit function is

$$\pi = pq - c(q) - ts = pq - c(q) - tcg^{t}q \quad (2)$$
[17]

where

p = given price

c(q) = total cost for producing q (fixed cost is not distinguished[18].)

t = CO_2 tax per unit of emissions

g^t = energy intensity with the tax

If the firm is entitled to subsidies when the subsidy ratio is v, its profit function is

$$\pi = pq - c(q) + v(\underline{s} - s) = pq - c(q) - vs + v\underline{s} = pq - c(q) - vcg^{v}q + v\underline{s} \quad (3)$$
[19]

where

v = subsidy per unit of CO_2 emission reduction

g^v = energy intensity with the subsidy

$\underline{s}$ = base emissions against which reduction is calculated

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15 IEEJ (2004).

16 Ito, Murota, Morita and Hoshino (2000, pp. 15) noted that energy conservation can contribute to CO_2 emissions reduction more than the introduction of renewables, which can be viewed as fuel switching.

17 Baumol and Oats (1998, pp. 214) and Hanley, Shogren and White (2007, pp. 87). The main difference from these studies is the explicit inclusion of energy intensity and the emission coefficient in the present analysis. In addition, for simplicity, I have explicitly excluded Baumol and Oats' abatement cost.

18 Varian (1992) stated that "all costs are variable in the long run".

19 Baumol and Oats (1998, pp. 215) and Hanley, Shogren and White (2007, pp. 97), with the same difference as for Note 17.

If the firm is subject to emissions trading and can sell emissions allowances when the price is r^c in the event of compliance, its profit function is

$$\pi = pq-c(q)+r^c(\underline{s}^r-s) = pq-c(q)-r^c s+r^c \underline{s}^r = pq-c(q)-r^c cg^c q+r^c \underline{s}^r \qquad (4)$$[20]

where

r^c = price of emissions allowance in the event of compliance

$\underline{s}^r$ = initial allocation of emissions allowance

g^c = energy intensity with emissions trading in the event of compliance

If the firm is subject to emissions trading but has to pay a charge when charge per unit of excess emissions is r^n in the event of non-compliance, its profit function is

$$\pi = pq-c(q)-r^n(s-\underline{s}^r)=pq-c(q)- r^n s+r^n\underline{s}^r= pq-c(q)-r^n cg^n q+r^n\underline{s}^r \qquad (5)$$

where

r^n = charge per unit excess emissions

g^n = energy intensity with emissions trading in the event of non-compliance

For simplicity, and to make the comparison of each case easier, the following assumption is made.

$t= v = r^c= r^n$[21][22] and $\underline{s} = \underline{s}^r$ (6)

Equations (3) and (4) indicate that if the energy intensity is the same, the profit function of the subsidy is the same as that of emissions trading in the event of compliance.

Marginal and average costs without measures are as follows.

$MC = c'(q)$ and $AC = c(q)/q$ (7)[23]

Marginal and average costs with the tax are as follows.

$MC_t = c'(q)+tcg^t$ an $AC_t = c(q)/q+ts/q = c(q)/q+ tcg^t$ (8)[24]

Marginal and average costs with the subsidy are as follows.

$MC_v = c'(q)+vcg^v$ and $AC_v = c(q)/q+v(s-\underline{s})/q = c(q)/q+vcg^v-v\underline{s}/q$ (9)[25]

Marginal and average costs with emissions trading in the event of compliance are as follows.

$MC_c = c'(q)+ r^c c\, g^c$

and $AC_c = c\,(q)/q+r^c(s-\underline{s})/q = c(q)/q+r^c cg^c-r^c \underline{s}/q$ (10)

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20 Taken from Kiyono (2007), who defines profit function using the equation $\pi = px-C(x,z)-r(z-\underline{z})$, where market price of the product is p, total cost of production is C, unit price of emissions allowance is r, amount of emissions is z, and initial allocation of emissions allowance is $\underline{z}$.

21 The MOE (2008, pp. 6) states that the charge should be sufficiently high compared to the allowance price in the event of compliance.

22 Unfortunately, due to this assumption, the possible problems with price fluctuation in the case of emissions trading indicated by METI (2008) cannot be analysed.

23 Hanley, Shogren and White (2007, pp. 99).

24 Ibid. The present model explicitly includes energy intensity and emission coefficient.

25 Ibid.

Marginal and average costs with emissions trading in the event of non-compliance are as follows.

$MC_n = c'(q)+r^n cg^n$

and $AC_n = c(q)/q+r^n (s-\underline{s})/q = c(q)/q+r^n cg^n-r^n\underline{s}/q$ (11)

The difference between Eqs. (10) and (11) is that the sign of $r^c(s-\underline{s})/q$ becomes minus, while the sign of $r^n (s-\underline{s})/q$ becomes plus.

Since the tax and emissions trading in the event of non-compliance tend to exacerbate the foundry industry's characteristic low profit and lack of funds, especially given a high energy price, the introduction of new equipment with advanced energy conservation technology would be very difficult. Therefore, the following assumptions are made.

$g= g^t = g^n$ (12)

However, in the case of a typical subsidy, which is a tax incentive, new equipment with advanced technology that improves energy intensity is introduced. This kind of subsidy tends to provide more funds to firms.[26]. Additionally, in the case of emissions trading in the event of compliance, the introduction of new equipment could be facilitated to reach compliance. Due to expected revenue from the sale of emissions allowances, funds for the introduction of equipment may also be easier to obtain. Therefore, the following assumptions are made. The $g^v = g^c$ assumption is made for simplicity.

$g = g^t = g^n>g^v = g^c$ (13)

3.4 Domestic Analysis

3.4.1 Possible impact of the tax

Figure 1 illustrates long-run impact of the tax on the Japanese foundry industry.[27][28] The chart on the left provides a firm-level analysis. As Eqs. (7) and (8) indicate, the tax shifts both marginal and average costs upward. Due to this shift, the exit of firms would take place until economic profit becomes zero ($AC_t = P_t$). As a result of this exit, q^{ti} (industrial output with tax) would be smaller than q^i (industrial output without tax), as

[26] Komiya and Yokobori (1990) argued that tax incentives tend to encourage financing from private banks.

[27] Taken from Hanley, Shogren and White (2007, pp. 98-99), with modifications to the contents of AC_t and MC_t, as indicated in (8). In addition, the model is applied to a specific industry (i.e., the foundry industry).

[28] Here, well behaved cost functions are assumed and should be verified by empirical analysis. Additionally, a constant cost industry is assumed for simplicity. An increased or decreased cost industry assumption would not fundamentally change the result, because the distance between industry supply curves is constant, a point which seems to be critical.

indicated in the chart on the right. The most important point appears to be the minimum value of AC, which decides the industrial supply curve and output. A higher minimum AC value indicates a lower industrial output. Since Eq. (12) assumes $g = g^t$, s^{ti} (industrial emissions with the tax) = $cg^t q^{ti} < s^i$ (industrial emissions without the tax) = $cg\, q^i$ (14), which means that the tax can decrease industrial emissions in the long run.

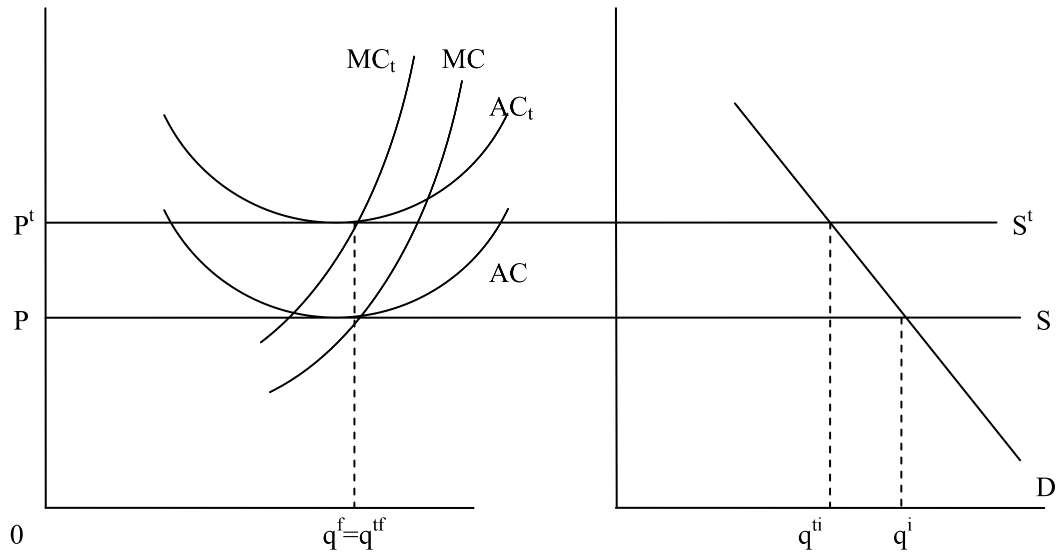

Figure 1. Long-run impact of the tax (firm and industry level)

However, in reality, the exit of firms from the foundry industry and the decrease in foundry production in Japan could be much more serious than that stated above, as more firms may exit due to negative economic profit. This is due to the power structure, in which user industries (e.g., the automobile industry) are much more powerful than the foundry industry, making price increases very difficult. Additionally, the lack of funds and low profit[29] characteristics of the foundry industry are compounded by high energy prices. In addition, if the foundry industry suffers, the automobile industry suffers, and if the automobile industry suffers, so does the steel industry, creating a vicious circle.

[29] Here, profit means accounting profit; economic profit should be even lower.

3.4.2 Possible impact of the subsidy

Figure 2 illustrates the long-run impact of the subsidy in comparison with the tax[30]. As indicated by Eqs. (6), (7), (8), (9), (12) and (13), in the case of the subsidy, the marginal cost curve lies between MC and MC_t. As Eq. (9) indicates, the subsidy shifts the average cost downward. Due to this shift, the entry of firms would take place until economic profit becomes zero, or $AC_v = P_v$. Due to this entry, q^{vi} (industrial output with the subsidy) would be larger than q^i (industrial output without measures), as shown in chart on the right, although each firm would produce less output, as shown in the chart on the left.

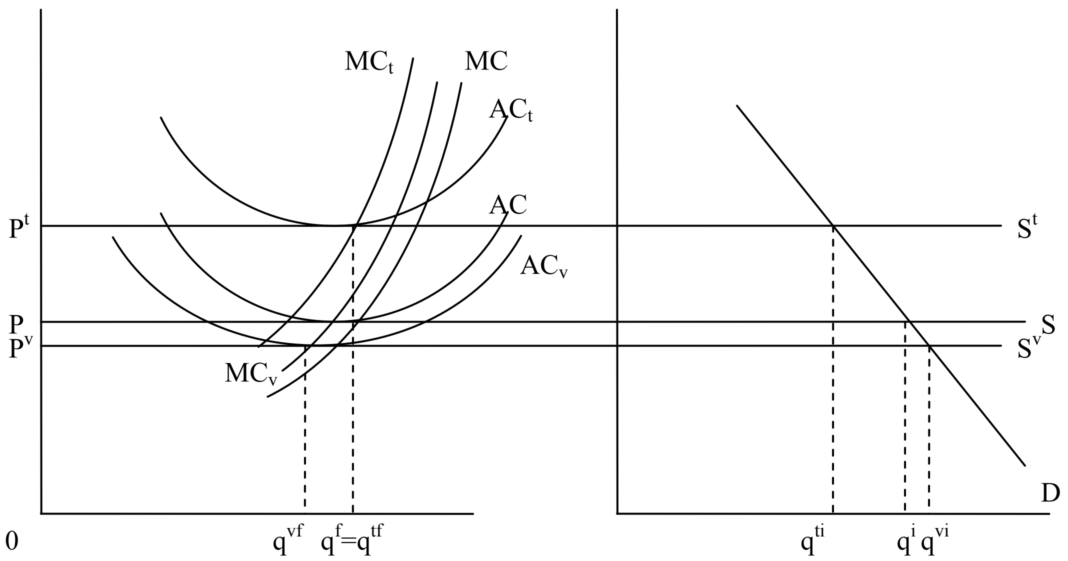

Figure 2. Long-run impact of the subsidy (firm level and industry level) compared to the CO_2 tax

However, a larger industrial output[31] does not necessarily mean more emissions. As Eqs. (1), (12) and (13) and Fig. 3 indicate, if the effect of a production increase, due to a potentially small average cost decrease[32], is outweighed by an improvement in

30 Baumol and Oats (1998, pp. 218-221) and Hanley, Shogren and White (2007, pp. 98-100). The main difference between these works is the location of MC_v due to energy intensity improvement and the horizontal industry supply curve, which is only used by Hanley, Shogren and White.Additionally, the contents of AC_v and MC_v are different, as indicated in Eq. (9).

31 This result is identical to both Baumol and Oats (1998, pp. 221) and Hanley, Shogren and White (2007, pp. 100).

32 Komiya and Yokobori (1990) argued that “tax incentives have only very limited effects on cost conditions in the private sectors”.

energy intensity, it is possible that emissions can be reduced by the subsidy[33].

It might be argued that, given the serious deficit faced by the Japanese government, the introduction of subsidies would be difficult. However, if the subsidy contributes to boosting the economy by increasing investment, tax revenue increases could outweigh the increase in government costs.

A common argument against subsidies is that they violate the polluters-pay-principle (PPP). However, it should be noted that foundry products must be produced somewhere, and that production in Japan would at least create the smallest amount of emissions.

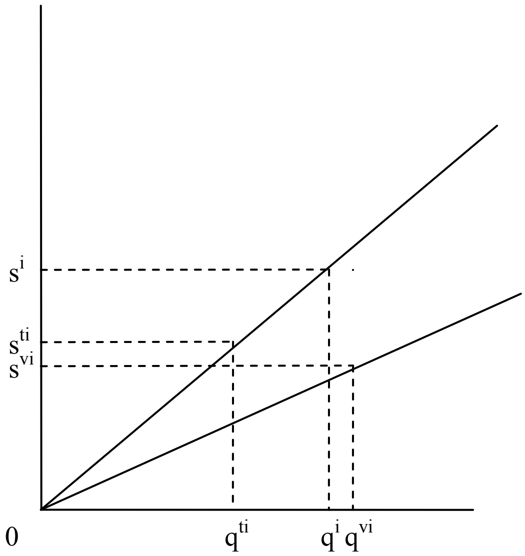

Figure 3. Possible emissions reductions with the subsidy

3.4.3 Possible impact of emissions trading

As indicated in the basic framework above, in the case of emissions trading, the event of compliance will be distinguished from the event of non-compliance as follows.

3.4.3.1 Possible impact of emissions trading in the event of compliance

Figure 4 illustrates the long-run impact of emissions trading (in the event of compliance) in comparison with the tax and the subsidy. Since $g^v = g^c$ is assumed, the result is the same as that of the subsidy.

Additionally, if the effect of production increase due to average cost decrease is

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33 This is a major difference between Baumol and Oats (1998, pp. 221) and Hanley, Shogren and White (2007, pp. 100).

outweighed by improvements in energy intensity, there is the possibility of emissions reduction by emissions trading in the event of compliance, similar to that seen for the subsidy in Fig. 5.

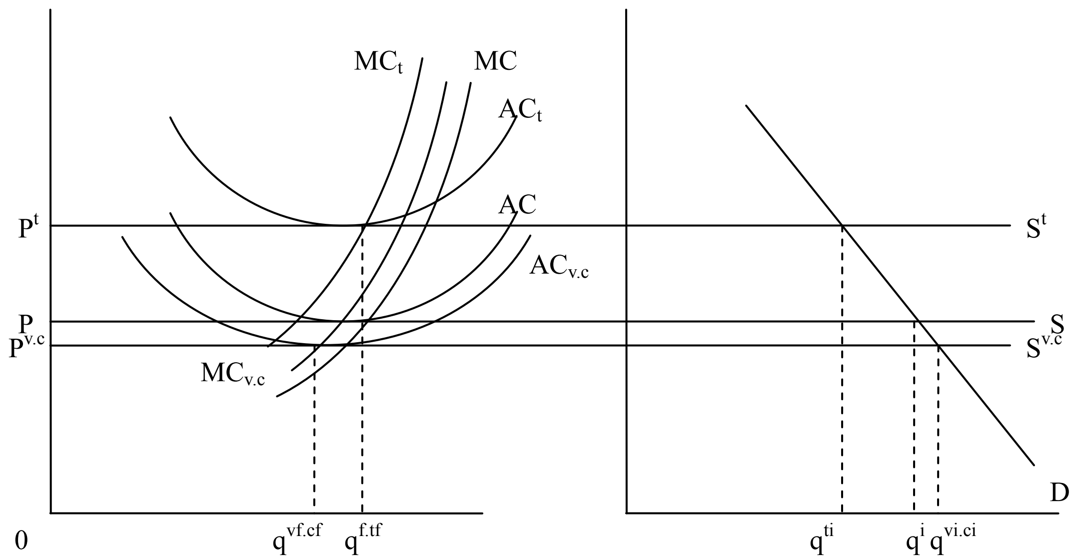

Figure 4. Long-run impact of emissions trading (in the event of compliance) compared with the CO_2 tax and the subsidy

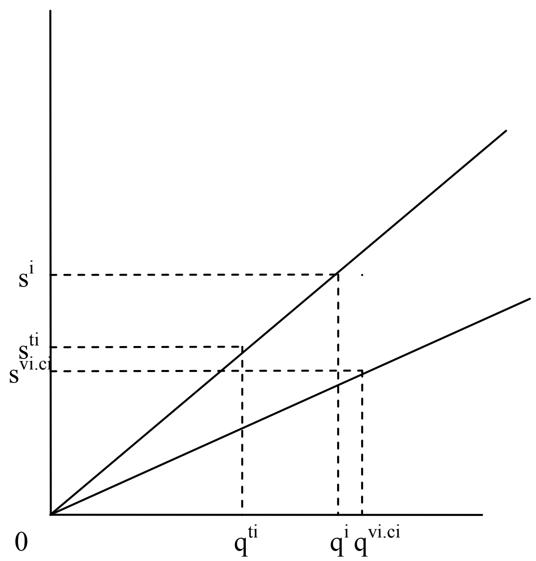

Figure 5. Possible emissions reduction with emissions trading in the event of compliance

Therefore, emissions trading in the event of compliance might have the same impact as the subsidy; Hongo (2008), for example, regards emissions trading as market-oriented subsidies. However, the expected serious difficulties in implementation stated in Sec. 3.2 should again be applied in this case.

3.4.3.2 Possible impact of emissions trading in the event of non-compliance

Figure 6 illustrates the long-run impact of emissions trading (in the event of non compliance) in comparison with other measures. Since $g^t = g^n$ is assumed, MC is the same as that for the CO_2 tax case, and, due to this charge, the average cost is shifted upward.

However, the magnitude would be smaller, since the firm would be responsible for the excess only as indicated in Eqs. (8) and (11). Due to this shift, the exit of firms would take place until economic profit becomes zero, which means that $AC_n = P_n$. As a result of this exit, q^{ni} (industrial output with the emissions trading in the event of non-compliance) would be smaller than q^i (industrial output without measures) as indicated in chart on the right. Since Eq. (12) assumes $g = g^n$,

$$s^n = cg^n q^{ni} < s^i = cg q^i \tag{15}$$

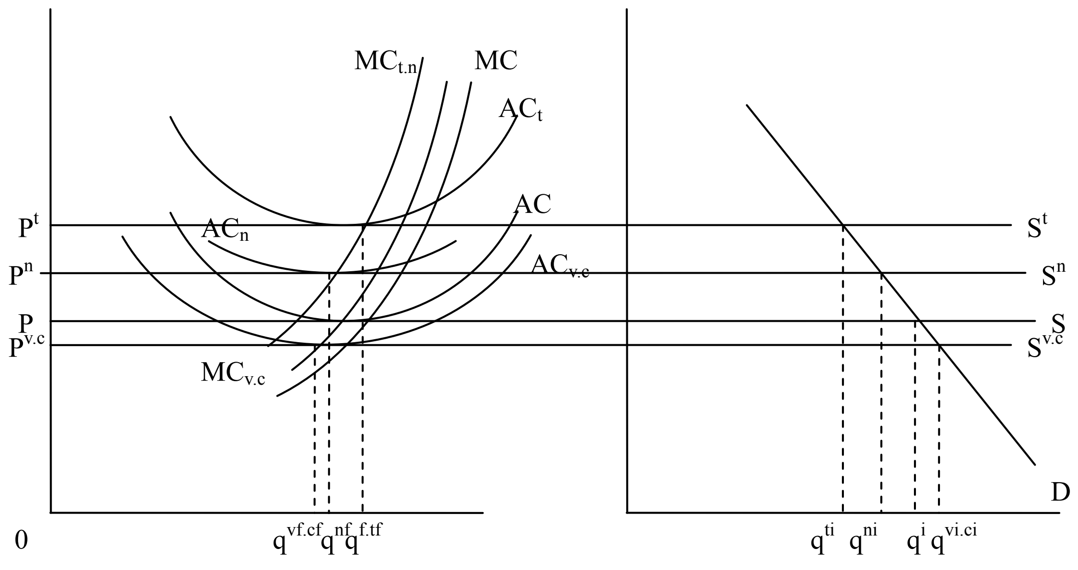

Figure 6. Long-run impact of emissions trading (in the event of non-compliance) in comparison with other measures

when s^n is industrial emissions with emissions trading in the event of non-compliance and s^i is industrial emissions without measures, indicating that emissions trading in the event of non-compliance can decrease the foundry industry's emissions in the long run.

However, in reality, the exit of firms from the foundry industry and the decrease in foundry production could be even more serious than this result indicates. This is because many non-complying firms would be forced to exit due to the competition with complying firms resulting from the cost and price difference (i.e., the difference between P^n and P^c in Fig. 6). It should be noted that this exit would be more serious under benchmark method, because weak firms would be unable to comply, as described in Sec. 3.2. Additionally, the expected serious difficulties in implementation stated in Sec. 3.2 should again be applied.

3.5 Global analysis of policy differences among countries

3.5.1 Possible impact of a tax introduced only in industrialised countries

Figure 7 illustrates the possible impact of a tax introduced only in industrialised countries. Script in is industrialized countries and script d is developing countries. Due to the cost and price difference illustrated by the difference between P^{in} and P^d, foundry industry in industrialised countries would disappear[34]. As a result, all foundry products

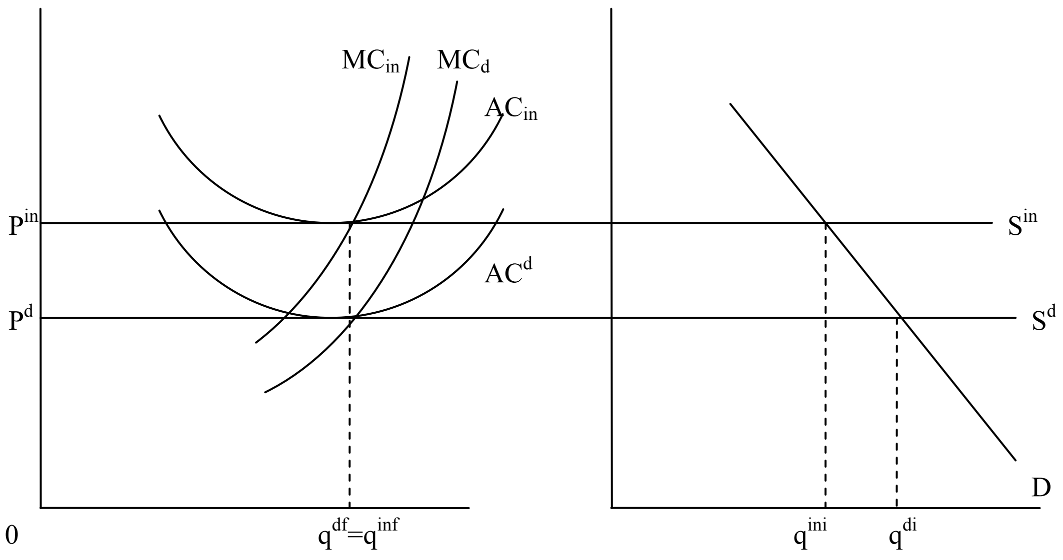

Figure 7. Possible impact of a tax introduced in industrialised countries only

would be produced in developing countries. Although zero emissions would be realised

34 In reality, due to quality differences between industrialised and developing countries, at least some firms in industrialised countries would survive, especially in the area of high-quality products.

in industrialised countries, it might cause serious unemployment problems, The amount of global production is thus the same as that before the tax.

However, in reality, global emissions would be increased, because it is reasonable to assume that both energy intensity and emissions coefficient are worse in developing countries due to lower levels of energy conservation technology and greater dependence on coal particularly in China and India, which together constitutes the majority of the developing world.

3.5.2 Possible impact of subsides introduced in only part of the world

Figure 8 illustrates a possible impact of a subsidy introduced in only part of the world[35]. Due to the cost and price difference illustrated by the difference between P^v and P, only foundry industries in countries where subsidies are introduced would survive[36], while the amount of global production would increase.

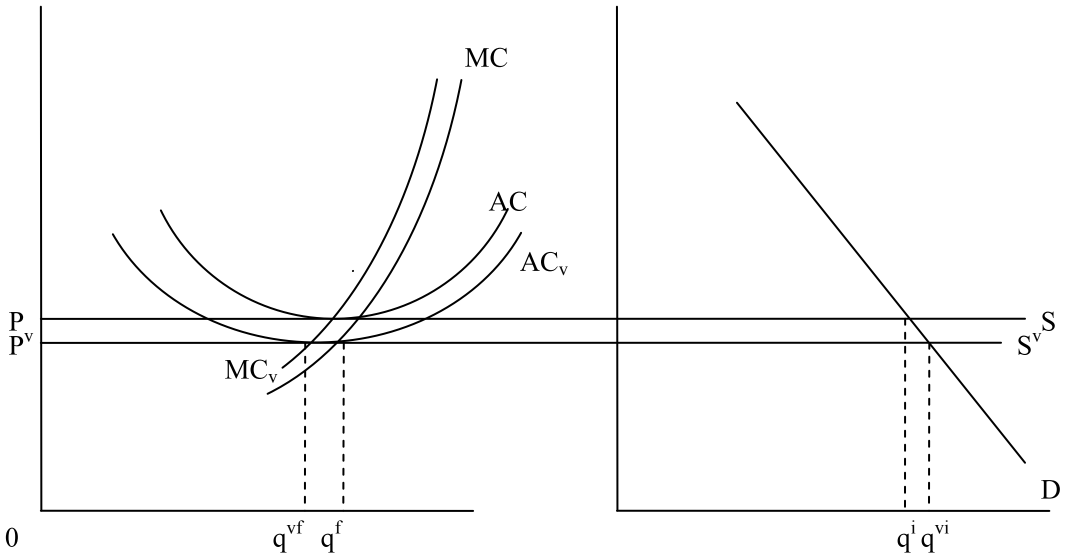

Figure 8. Possible impact of a subsidy introduced in only part of the world

However, a larger industrial output does not necessary mean more emissions, as discussed in Sec. 3.4.2. If the effect of a production increase due to an average cost decrease is outweighed by improvements in energy intensity from the introduction of equipment technology, emissions can be reduced by a subsidy. Additionally, the most

35 The industrialised-developing distinction is not made here, because subsidies appear to be common to both types of countries.

36 In reality, due to quality differences among countries, at least some firms in countries where subsidies are not introduced would survive, especially in the area of high-quality products.

advanced energy conservation technology for equipment could be introduced not only in industrialised countries but also in developing countries, which currently have much higher energy intensities than industrialised countries. As a result, dramatic global emission reduction is a possibility. It may be argued that, as a result of subsidy competition, only industries that receive huge amounts of subsidies would be able to survive. However, I tend to think that this would be unlikely, as it is widely considered among policy makers that huge amount of subsidies are ineffective, and because tax incentives have only very limited effects on cost conditions in the private sector (see Note 32).

Concerning polluters-pay-principle (PPP), as argued in Sec. 3.4.2, foundry products must be produced somewhere, and the subsidy could contribute significantly to global emissions reduction. Thus, it may be preferable to encourage production by lower energy intensity producers using subsidies, which would ultimately contribute significantly to global emissions reduction.

3.5.3 Possible impact of emissions trading within the Kyoto framework

For simplicity, the following assumptions were made:[37] (1) Foundry industry firms in countries unable to reach Kyoto targets would not be compliant and (2) firms in countries able to reach Kyoto targets would be compliant, because allowances are likely to be more strict in countries that could not achieve these targets.

Figure 9 illustrates the possible impact of emissions trading within the Kyoto framework. Due to the cost and price difference illustrated by the difference between P^n and P^C, the foundry industries in non-compliant countries would disappear, and only those in compliant countries would survive[38]. Although the amount of global production would be increased, if the effect of production is outweighed by improvements in energy intensity, global emissions could be reduced by emissions trading.

However, there would be very serious impacts on the foundry industries in non-compliant countries, among them unemployment. Additionally, the serious difficulties in implementation described in Sec. 3.3 would be expected.

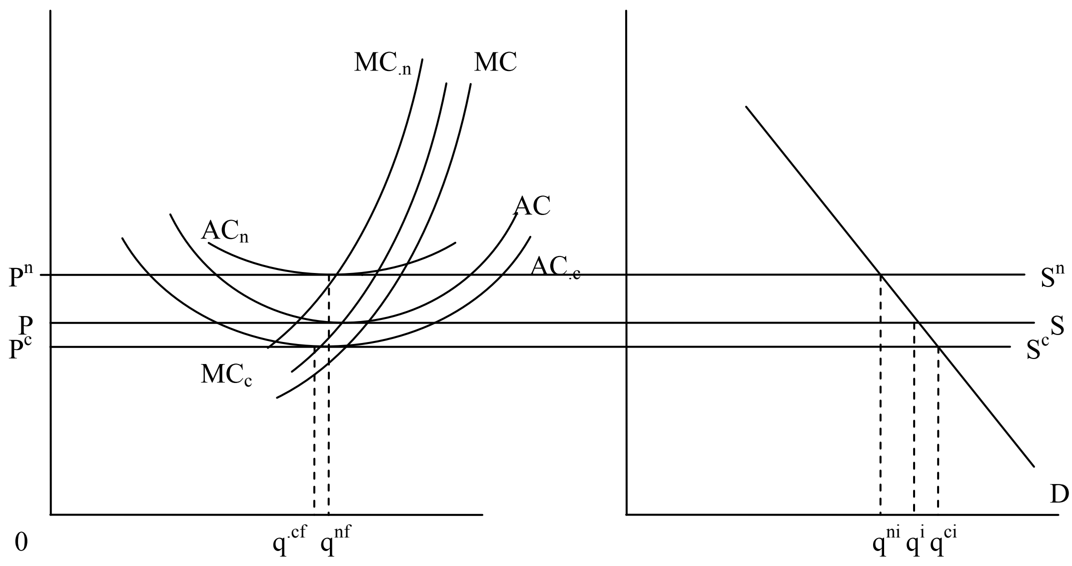

Figure 9. Possible impact of emissions trading within the Kyoto framework

[37] Countries not included in the Kyoto framework, which create the majority of global CO_2 emissions, were excluded from this analysis.

[38] In reality, due to quality differences among countries, at least some firms in countries not complying with the Kyoto Protocol would survive, especially in the area of high-quality products.

4. Summary and conclusions

The long-run impact of a CO_2 tax, subsidies for CO_2 emissions reduction and CO_2 emissions trading on the foundry industry, both globally and domestically, was examined using partial equilibrium analysis. Significant findings were as follows.

Although it would decrease domestic emissions, implementation of the CO_2 tax could have serious impacts on the Japanese foundry industry. If the tax is introduced in industrialised countries only, it would increase global emissions and have serious impacts on the foundry industries in those countries.

The subsidy could decrease emissions both domestically and globally without hurting foundry industries, and could improve their productivity by decreasing energy intensity.

Emissions trading could theoretically work like a subsidy in the event of compliance and qualitatively work like a tax in the event of non-compliance. In the event of non-compliance, which is more likely to happen in the foundry industries in Kyoto non-compliant countries, serious impacts on the foundry industries would occur. Additionally, serious difficulties in implementation are expected.

As indicated by $s = cgq$ in Eq. (1), there are 3 ways to decrease CO_2 emissions.

The first way is to decrease foundry output (q). However, this appears extremely unlikely due to the high projected global economic growth in current developing countries[39] which is expected to increase global automobile, [40] and thus foundry, production.

The second way is to decrease the emission coefficient (c), which means fuel switching. However, most energy experts believe that this approach is limited. For example, overdependence on renewables might cause problems concerning energy security in foundry production.

The third way is to decrease energy intensity (g). This method seems to be most effective and realistic, because it could also contribute to economic growth through improvements in foundry industry productivity and energy security.

The subsidy for introducing energy conservation technology equipment to the foundry industry could contribute to the reduction of CO_2 emissions, economic growth (both by productivity growth due to energy intensity improvement and increase in

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[39] Ito, Murota, Morita and Hoshino (2000, pp. 6) postulate that current developing countries will enjoy high growth in the long run.

[40] The research results of the IEEJ, in which I was involved in 1999, indicate that there is a strong correlation between per capita income and automobile diffusion rate in many countries.

investment in equipment technology), and energy security.

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