**EXPLORING THE VIABILITY OF AN EMISSION TAX POLICY FOR SHIPS AT BERTH IN TAIWANESE PORTS**

Po-Hsing Tseng\*

Department of Transportation Technology and Management, Feng Chia University, No. 100, Wenhwa Road, Taichung 40724, Taiwan

Email:phtseng@fcu.edu.tw

\*Corresponding author

Nick Pilcher

The Business School, Edinburgh Napier University, Craiglockhart Campus, Edinburgh, UK

Email: N.Pilcher@napier.ac.uk

**Biographical notes:** Po-Hsing Tseng is an Assistant Professor in the Department of Transportation Technology and Management at Feng Chia University. His current research interests include green shipping and green logistics.

Nick Pilcher is a Lecturer in The Business School at Edinburgh Napier University and programme leads the MSc in Intercultural Business Communication (with TESOL). His current research interests include language; qualitative research methods; and education.

**ABSTRACT**

This paper considers an emissions tax to help limit external air pollution from ships in Taiwanese ports through a mixed methods research (MMR) approach. Through an empirical bottom-up activity-based model, external air pollution costs are estimated for 7 types of ships at berth during 2012 in the three largest Taiwanese container ports. Results show pollutants are both measurable and serious in scale, i.e. that such a tax is theoretically valuable and viable. To investigate introducing such a tax at a practical policy level, qualitative in-depth interviews were conducted with fifteen experts: port operators and government officials. Their perceptions reveal many significant tensions regarding the practicality of an emissions tax, such as a need to introduce it globally, and the idea that it may be unnecessary given other initiatives can create port sustainability. Based on these results, possibilities and considerations for the implementation and study of sustainable port operation are made.

**Key Words**: Ship; Port; Emission Tax

1. **INTRODUCTION**

Port pricing policy is becoming increasingly environmentally orientated. Ship emissions are viewed as negative externalities or even market failure when their external costs are not reflected in market prices, and therefore, lead to inefficiencies in resource allocation. When ships dock at port, ship boilers still generate electrical power through auxiliary engines to provide ship’s basic operations, such as lighting, refrigeration, cooling, pumps, elevators and essential equipment. During the berthing period, cargo handling equipment (e.g. rubber tired gantry and straddle cranes) at dockside are used to transfer cargo (e.g. container) to trucks or railcars and carry them away from the port. A ship’s emissions depend on how long it berths at port. To reach the principle of user-pay, actual market price should fully consider environmental costs; a Pigouvian charge should arguably be imposed on ship users. Indeed, welfare economics indicates markets achieve maximum economic efficiency when price equals marginal social costs and considers externalities (Pigou, 1920).

To date, however, little research has calculated emissions taxes for pollution producers from port. This current paper complements research by Chang and Wang (2012) that evaluated the effects of green port policy in Kaohsiung. Using a bottom-up activity-based model, it estimates external air pollution costs based on ships at berth during the year 2012 in the three largest Taiwanese container ports: Kaohsiung, Keelung and Taichung. This data is then contextualized within the perspectives of government officials and port operators regarding the practicality of such a tax gathered through in-depth qualitative semi-structured interviews. Subsequently, suggestions for possible policy actions and considerations regarding the possibility of an emissions tax, and of port sustainability in general, are made.

1. **STUDIES OF SHIP EMISSIONS AT BERTH**

Many studies recognize ship emissions as significant sources of air pollution and greenhouse gases (Lonati et al., 2010; Villalba and Gemechu, 2011). Based on a study in the port of Piraeus (Greece), Tzannatos (2010a) showed that ship emissions at berth determined the concentration of exhaust emissions in ports and, significantly, are three to five times higher than emissions from other activities (e.g., maneuvering and cruising) during the various seasons in ports.[[1]](#footnote-1) Similar evidence was found in Candarli Gulf (Turkey) (see Deniz et al., 2010).[[2]](#footnote-2) Understandably, this has become a great concern for port authorities.

Several studies estimate ship emissions in ports. Deniz and Durmusoglu (2008) estimated shipping emissions (CO2, NOx, SO2, CO, VOC and PM) in the Sea of Marmara and the Turkish Straits for 2003. Similarly, Lonati et al. (2010) calculated ship emissions at berth for a new port in the Mediterranean. However, from a transportation economics perspective, most studies have only estimated emissions, not considered external costs, monetary values, or environmental impacts on society. Attempts to cost ship pollution have mainly focused on specific ship categories (Tzannotos, 2010b; Isensee and Bertram, 2004). Other studies have surveyed European zones such as Italy, the Netherlands, and Sweden (Geerlings and Duin, 2011; Lonati et al., 2010; Miola and Ciuffo, 2011; Winnes and Fridell, 2010). Yet, external costs of ship emissions in Asia’s ports have only rarely been investigated, despite these ports now being global production and consumption centers. Nevertheless, one Taiwanese study (Berechman and Tseng, 2012) estimated the environmental costs of port related emissions in Kaohsiung. Using a bottom-up methodology, the combined environmental costs of ships and trucks were estimated to be over $123 million per year. Yet, ship users did not pay such environmental costs and thus caused negative externality.

Regarding the wider field of vehicle users’ responsibility for such costs, many studies exist. Based on Pigou (1920), taxation is arguably effective to internalize externality. Hammar and Jagers (2007) examined how individual preferences for fair reductions of CO2 emissions affected support for CO2 tax increases on gasoline and diesel. They found the relative importance of fairness principles depends on frequency of car use. Further, Mayor and Tol (2007) surveyed the recent doubling of air passenger duty in the UK on CO2 levels and visitor numbers and found, counterintuitively, that CO2 emissions actually increased, albeit only slightly, through reducing relative price differences between near and far holidays. Further, Kim et al. (2011) showed in the Korean transportation sector that when a gasoline focused CO2 tax is charged at an additional ₩50,000 (equivalent to $54 in US dollar of 2007) per CO2 ton, CO2 emissions can be reduced, through reduced vehicle use, between 916,124 (lower bound)~1,090,325 (upper bound) per ton. We complement this research with empirical work on emission tax pricing in port, drawing on insights from established economic theories to help compute the external costs of these emissions from ships. Further, we contextualize these findings through showing perceptions of government and port operator stakeholders regarding the practicality of an emissions tax. Our data intends to inform both theoretical and practical approaches to future port sustainability.

1. **DATA COLLECTION AND ANALYSIS**

Sea shipments constitute over 99% of Taiwan’s total international trade. According to the ship data provided from three port authorities,[[3]](#footnote-3)&[[4]](#footnote-4) the database contains information on ship movements, including ship type, number of calls, time spent in berth and other information.In 2012, 28,139 ships entered Taiwan’s three main ports: Kaohsiung, Keelung andTaichung. Table 1 shows the ship-type distribution. Kaohsiung, in the south, is the largest port in Taiwan, accounting for 54.17% of ship calls. Taichung port and Keelung port accounted for 22.14% and 20.72%, respectively. As Table 1 shows, containerships constituted the majority, followed by general cargo ships and tankers.

Table 1 Ship Type and Number of Calls in Three Ports of Taiwan (in 2012)

|  |  |  |  |
| --- | --- | --- | --- |
| Ship Type | Number of ship calls | Sub-total | Time spent at berth (hours) |
| Kaohsiung | Keelung | Taichung |
| Bulks | 1,367 | 734 | 705 | 2,806 | 144,807  |
| Containerships | 8,228 | 3,503 | 3,386 | 15,117 | 572,967  |
| General cargo ships | 3,260 | 801 | 1082 | 5,143 | 219,432  |
| Barges  | 28 | 4 | 15 | 47 | 2,020  |
| Tankers | 3,056 | 206 | 964 | 4,226 | 164,187  |
| Fishing ships | 210 | 78 | 30 | 318 | 17,962  |
| Passenger ships | 144 | 308 | 30 | 482 | 34,141  |
| Total | 16,293 | 5,634 | 6,212 | 28,139  | 1,159,390 |
| Percentage (%) of ship call | 54.17% | 20.72% | 22.14% | 100.00% |  |

Source: Ministry of Transportation and Communication, Taiwan <http://www.motc.gov.tw/en/index.jsp>

Combining quantitative and qualitative research approaches in a mixed methods (Teddlie and Tashakkori, 2011) research approach (MMR), four steps were used to explore the viability of an emission tax for ships at berth (see Figure 1 below). Step one estimated air pollution from ships at berth using ship data related to time spent, load factor and emission factor. Step two estimated external emissions costs by multiplying emissions amounts with monetary values of each pollutant. Step three computed a possible emissions tax through economic analysis, using the concept of average cost and marginal cost. Step four complemented this quantitative data and added a practical context through in-depth semi-structured interviews with port management field and government officials. These interviews considered potential barriers, limitations and problems (e.g. equity and acceptance or cost of implementation) based on areas highlighted, or salient, in the literature. They were conducted ethically in that approval was granted from the appropriate bodies and they were conducted anonymously (Christians, 2011) and were ‘active’ (Holstein and Gubrium, 1995) through the use of ‘spider diagrams’ (cf. Pilcher et al.*,* 2013) focused on the key issues (Appendix 1) regarding barriers, limitations and problems. Spider diagrams give power to the interviewee (cf. Foucault, 2000) by not framing questions (cf. Goffmann, 1975) in a particular way but leaving them open. This means that interviewer bias is reduced, as the interviewee has more control over the issues and direction of the interview. Actual questions were not preformulated and the discussion freely focused on the issues, and this also reduced interviewer bias as it removed the bias of directing the interview through specific or leading questions. Also, rather than use the quantitative figures in the interviews, we deliberately decided to explore perceptions without highlighting these, again to avoid any bias. Interviews were conducted in the participants’ native language thereby allowing greater expression (Cortazzi et al*.,* 2011) and then translated into English using a ‘skopos’, or goal centered, approach (Vermeer, 2004) to ensure as readable a translation as possible. Transcripts were coded and analyzed using a constructivist grounded theory approach (Charmaz, 2011) whereby themes emerged through analysis, and were then categorized appropriately.

Figure 1 Research Process

**3.1 Ship Data**

According to the ship data provided from three port authorities[[5]](#footnote-5), the database contains information on ship movements, including ship type, number of calls, time spent in berth and other information. It covers the period 1 January 2012 to 31 December 2012. Ships were categorized into seven types: bulks, containerships, general cargo ships, barges, tankers, fishing ships, and passenger ships. A maximum continuous rating engine power for each ship category was adopted from the International Maritime Organization (IMO) Energy Efficiency Design Index[[6]](#footnote-6) and is shown in Table 2 below.

Here we follow a widely used approach for calculating ship emissions (see Joseph et al., 2009; Tzannatos, 2010a) and several ship operation characteristics and emission factors were considered. These included ship type and category, power of ship’s auxiliary engines, engine load factor and time spent at berth. To calculate emissions we used the following expression:

 (1)

Where,

: pollutant type (NOx, CO, CO2, PM10, PM2.5, SO2, HC and VOC);

: ship category;

: the emissions from ships type, in tons ;

: the time at berth per calling for a certain ship category j (in hours);

:the mean load on the auxiliary engine(s) as a fraction of the engines’

 maximum installed engine power, where MCRj stands for “Maximum

 Continuous Rate” by a certain ship category;

: the load factor for auxiliary engines;

: emission factor for auxiliary engines (g/kilowatt-hour) for different pollutant .

Table 2 Maximum Continuous Rating for Various Ship Engines (kW)

|  |  |  |
| --- | --- | --- |
| MCRmain engine | >10,000 KW | <10,000 KW |
| Powerauxiliary Engine | =(0.025\*MCRmain Engine)+250 | 0.05\*MRCMain Engine |

Source: International Maritime Organization <http://www.imo.org/Pages/home.aspx>

The maximum continuous rating power of auxiliary engines for each ship size category was adopted from Deniz et al. (2010). Load factors varied by ship type and are shown in Table 3. Emission factors were categorized by different pollutants, as shown in Table 4.[[7]](#footnote-7)

Table 3 Load Factor for Ship

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Bulks | Containerships | General cargo ships | Barges | Tankers | Fishing ships | Passenger ships |
| 22 | 17 | 22 | 24 | 67 | 27 | 64 |

Source: Joseph et al*.* (2009); Starcrest consulting group (2008); Yau et al*.* (2012)

Table 4 Emission Factors for Ships at Berth

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| NOx | CO | CO2 | PM10 | PM2.5 | SO2 | HC | VOC |
| 10.8 | 1.1 | 745 | 2.4 | 2.4 | 12.7 | 1.5 | 0.4 |

Source: Deniz (2010); Dolphin and Melcer (2008); ENTEC (2007)

**3.2 Calculation of External Emission Costs**

External emission costs are based on the monetary valuation of air pollution. Total external costs of ship emissions are defined as the sum of the external costs of various pollutants. These are estimated by multiplying the amount of emissions and the monetary value of each pollutant (in dollars per ton), and time spent at berth, as shown in (3).

 (3)

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*i*

*i*

*i*

*M*

*E*

*C*

Where

: pollutant type (NOx, CO, CO2, PM10, PM2.5, SO2, HC and VOC);

: total external cost of ship emissions;

: annual amount of emissions for pollutant ;

: external cost for a certain pollutant (in dollars per ton).

**3.3 Computation of Emission Tax**

Based on the categories of ship types, we calculate monetary value per emission unit (per ship-hour at berth) and set it as the calculation basis of the emission tax. In order to do this, two computation processes were done. First, we estimated annual external costs for various ships through multiplying monetary value and annual volume for various pollutions emitted from ships. Second, through a process of dividing these annual external costs for various ships by the annual number of ships and hours in one year, the external costs of each type of ship per ship-hour were obtained, as shown in (4).

Emission Tax(j)= j: ship category (4)

1. **RESULTS**
	1. **External Cost Estimation**

Table 5 shows the 2012 distribution of total emissions for each pollutant and ship category. Notably, container ships, tankers and general cargo ships emit about 80% of the total pollutants. This is because these ships constitute the main ship calls in the ports surveyed. It is noted that although the number of ship calls and time spent at berth by Tankers are not the highest (see Table 1), due to their higher load factor (see Table 3), the actual ranking of emissions from these ship types is significantly higher. Regarding emissions distributions, the main pollutant, CO2, was found to be dominant throughout the surveyed year (59,438.9 ton).

Table 5 Annual Emissions of Pollutants by Ships (ton/year)

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Category | NOx | CO | CO2 | PM10 | PM2.5 | SO2 | HC | VOC | Sub-total |
| Bulks | 86.8  | 8.8  | 5988.5  | 25.3  | 19.3  | 102.1  | 12.1  | 3.2  | 6,246.0  |
| Containerships | 340.9  | 34.5  | 23,515.1  | 82.0  | 75.8  | 400.9  | 47.3  | 12.6  | 24,509.1 |
| General cargo ships | 123.1  | 12.5  | 8488.5  | 33.5  | 27.3  | 144.7  | 17.1  | 4.6  | 8,851.2 |
| Barges | 1.4  | 0.1  | 98.3  | 0.4  | 0.3  | 1.7  | 0.2  | 0.1  | 102.6  |
| Tankers | 335.7  | 33.7  | 23,156.8  | 96.9  | 74.6  | 394.8  | 46.6  | 12.4  | 24,151.5 |
| Fishing ships | 11.9  | 1.2  | 819.1  | 3.0  | 2.6  | 14.0  | 1.6  | 0.4  | 853.8  |
| Passenger ship | 41.3  | 5.0  | 3,361.1  | 17.6  | 10.8  | 57.3  | 6.8  | 1.8  | 3,501.7  |
| Total | 854.2  | 87.1  | 59,438.9  | 233.4  | 191.5  | 1,013.3  | 119.7  | 31.9  |  |

**4.1.1 Monetary Value of Pollutants**

 Following recent studies in external costs for ship emissions in Taiwan (e.g. Lee et al., 2010; Berechman and Tseng, 2012), the external costs (in US$) of key pollutants are 4992(NOx), 3(CO), 26(CO2), 375,888(PM10), 554,229(PM2.5), 13,960(SO2), 4.27(HC) and 1,390(VOC). A ship activity-based methodology (considering time spent at berth, load/emission factor for auxiliary engine power) is adopted to estimate emissions in this paper given its widespread application in other studies such as Tzannatos (2010a), Deniz (2010) and Hulskotte et al. (2010).

**4.1.2 External Costs of Ship Emissions**

Following the two-step process described in 3.3. above, and after multiplying the annual volume of pollutants by ship and monetary value for various pollutants, Table 6 shows the external costs of ship pollutants and total emission costs in 2012 are US$236.04 million. It should be noted that although the amount of CO2 represents the highest pollutant amount, its external cost per unit is relatively low compared to other pollutants, and its ranking as an external costs was therefore reduced.

Table 6 External Costs of Ship Emissions (in 2012)

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Pollutants | NOx | CO | CO2 |  PM10 |  PM2.5 | SO2 | HC | VOC |
| The amount of emissions (tons) | 941.1 | 95.8 | 65,427.4 | 258.7 | 210.7 | 1115.5 | 131.7 | 35.1 |
| External cost (dollar/ton) | 4,992 | 3 | 26 | 375,888 | 554,229 | 13,960 | 4.27 | 1,390 |
| External costs of pollutant\*  | 4,698 | 0.3 | 1,701 | 97,242 | 116,776 | 15,572 | 0.6 | 49 |
| Total external costs | $236.04 million |

Note:\* US$ 1,000

From an economic viewpoint, these results quantify the degree to which pollution externalities are social costs that should be borne by both suppliers and users of ships and trucks. To internalize these costs a Pigouvian Tax (Pigou, 1920) should arguably be imposed on polluting activities, thereby reducing ships’ non-optimal activity, i.e., activities whose marginal social costs exceed their marginal social benefits. Since ship emissions depend on time at berth, time is a key factor affecting the magnitude of pollution costs. The longer the time, the higher the pollution costs. Table 7 shows the tax arrangements by ship type. The emission tax imposed on ships[[8]](#footnote-8) is ranked by passenger ships[[9]](#footnote-9), tankers, fishing ships, bulks, barges, general cargo ships and containerships.

Table 7 The Emission Tax (US$ dollars) of Various Ship Types (per ship-hour)

|  |  |  |  |
| --- | --- | --- | --- |
| Category | Number of ships in 2012 | Pollution costs (US$) | Pollution costper ship-hour(US$ dollars) |
| Passenger ships | 482 | 13,697,314  | 3.24  |
| Tankers | 4,226 | 85,575,866  | 2.31  |
| Fishing ships | 318 | 2,845,367  | 1.02  |
| Bulks | 2,806 | 22,225,435  | 0.90  |
| Barges | 47 | 350,041  | 0.85  |
| General cargo ships | 5,143 | 30,584,432  | 0.68  |
| Containerships | 15,117 | 80,760,923  | 0.61  |

Thus, this quantitative data shows justified evidence and calculations of emissions tax and monetary and social pollutant costs. To contextualize these possibilities in the practical policy arena, we now present and discuss the perceptions of government officials and port operators regarding the practicality of an emissions tax.

**4.2. Perspectives of Port Operators and Government Officials**

Regarding experience and job type, the port operators (8) we interviewed averaged 21 years’ experience, ranging from 17 to 30 years, and their job types included senior posts, not revealed here to ensure anonymity. Government officials (7) we spoke to averaged 23 years’ experience, ranging from 10 to 30 years, and their job types also included senior posts. We categorize the results below into thoughts on emissions tax, and wider issues. We have selected a number of quotes and woven these into a narrative. Each section ends by summarizing the main issues that arose before the paper ends with a discussion of these results and a conclusion.

**4.2.1. Thoughts on Emission Tax – Port Operators**

For port operators, cost and profit were key, and an emissions tax was perceived to potentially affect business negatively, in that *“shipping operators will consider operation cost, if they cannot get profit for a long time, they will withdraw the shipping line.”* Further, that *“if the government would like to levy emission tax, it will increase the cost burden.”* Who should pay the tax was a divisive issue, one port operator underlining that their company *“cannot be responsible for all cost. Otherwise we cannot convince our shareholder… we must be very careful to think about the emission tax policy”*, although another conversely noted that *“emission tax should be paid by ship owner.”* Indeed, government subsidy was considered divisive, as, *“today if we levy the taxes and subsidy certain ships, then unsubsidized ship owners will complain… the ship will not call at Taiwan, it will affect export/import material and cargo.”*

Regarding berth time duration issues, specific ship-type was noted. Wider issues were also considered, for example, *“operation time is different due to the type of cargo”*, and that if low sulfur fuel price for the ship’s electricity generating engine is high *“the ship owner will not buy it.”* Further, any calculation *“should consider truck time. Trucks may be affected by traffic jam and then the cargo cannot (un)load.”* Another participant stressed the complexity involved, noting *“the level of pollution of various ships is different; also, not every ship pollutes the port continually from berthing to leaving port. Hence, shipping operators will complain if the government levies the emission tax based on berth time.”*

Operators noted issues we had considered (and some we had not) in our quantitative calculations: *“Is it calculated by ship tonnage or fuel? Does it consider the shore power?* *How long does it use? What is the reduction effect of emission? Is there any basis (or rule) to ban it? What is the standard of tax levy? They* [should] *also consider ship type and engine.”*

Further, significant practical issues not included in our quantitative calculations were also mentioned. For example the need to check other port’s policies to emissions tax: *“if it is not conducted in other countries and we conduct it in Taiwan, it will increase the cost burden for ship owners. It is a big problem.”* Another operator stressed taxes should also be considered outside of ports: *“the governmental regulation involves port, road and airport.”* Also, actual ability to monitor air quality was questioned. Although some felt this could be monitored, one operator felt data gathering *“suffer*[s] *from the problem of checking and identifying air pollution as the technique is not mature now.”* One participant also noted, rightly, that wind direction could affect pollution levels: *“Sometime the wind direction will affect the air pollution. For example, when the wind is strong in Singapore, the air pollution will affect Malaysia and Indonesia.”*

Another issue not in our quantitative calculations was the ‘short-term – long-term’ element. One operator noted that *“in the long term, it is beneficial for the overall environment and sustainable development”* but that *“currently, levying emission tax will increase the cost of ship owner when calling at Taiwan. It is not good to compete with other country’s port.”* This operator said it would not work now *“without any supportive strategies which consider the nation’s economic development”,* an approach which would need to consider (see above) that subsidies may create resentment amongst those not receiving it.

In addition, many operators felt an emissions tax was in basic principle unnecessary, for example, *“actually, it is not necessary to conduct this kind of tax. There are many methods that can achieve the mitigation target of air pollution... tax is just one of them.”* This participant also noted that a tax could actually be counterproductive in environmental terms as, *“someone may think “I already pay the tax, I can continue to pollute the port””.* Similarly, another participant noted other methods would be more effective than an emissions tax to improve the port environment: *“I do not agree that it is necessary to levy tax to improve port environment. It is more important to create suitable environment that shipping operators would like to reduce pollution.”*

It can be concluded based on the above that, in the accurate words of one operator, introducing an emissions tax, *“is a serious question. We must deal with it very carefully as it affects our country’s economic development.”* Key issues from the perspectives of port operators were the tension between cost and profit, who should pay the tax, and whether it should be subsidized (and if so, who should be subsidized), whether different ship types should pay different taxes, and the need to investigate what other ports elsewhere were doing. Further, the issue of whether the whole process of delivery should be taxed was raised, as were issues of how to measure emissions and also the actual idea, from port operators’ perspectives, that such a tax may not be necessary.

**4.2.2. Thoughts on Emission Tax - Government Officials**

Unlike port operators, government officials rarely mentioned profit. They were not specifically asked about it, but the fact that there was little mention of it arguably shows the different frames (cf. Goffman, 1975) the two groups had: for port operators profit was the major priority, for government officials, the environment was the major priority. Nevertheless, many commonalities existed, and officials indirectly highlighted profit, for example by noting the need for careful preparation before introducing such a ‘tax’ (cf. operators’ ideas of short-term and long-term). One official cautioned that if the tax was introduced now, *“shipping operators will protest this policy because the purpose of this tax is not clearly explained now.”* This official further stressed a wide range of stakeholders should be first consulted: *“we need to invite stakeholders, such as environmental authorities, academic experts and practical experts, payers, tax collectors, ship-owners, ship agents, engine manufacturers, fuel suppliers, and to then discuss reasonable payment methods and standards.”* Another official emphasized the need to collect data on practices in other countries: *“we should collect more data about other countries.”*

Similarly to operators, officials said much to corroborate our quantitative analysis. One official noted sulfur was particularly dangerous, and that *“in the Emission Control Area, the content of sulfur in any fuel should not exceed 1.0% m/m.”* Another mentioned procedures very similar to those we adopted in our quantitative analysis, and that based on someone exceeding the value of the concentration of NOx, *“we could levy emission fee based on the content ratio of sulfur in the SOx. Therefore, it could calculate the volume of SOx and transform into hour-emission volume. Finally, we could calculate the emission fee according to berth time in the port.”*

However, and similarly to operators, officials noted the importance of other factors. One official noted that the entire shipping process contributed much pollution and should be considered, saying “*besides ship source, it includes loading/unloading equipment, transportation vehicles, tanks and storage and chimneys. Therefore, we should clearly identify all emission sources.”*

Also, many officials also questioned the actual need for any emissions tax. One said that laws already existed to monitor emissions, and another felt that controlling fuel usage would be more effective: *“we could consider the method of vehicle gasoline/diesel fee to levy by fuel consumption.”* This was echoed by another official: *“if we control the source of fuel usage, air pollution will gradually decrease.”*

Thus, similarly to the port operators, if somewhat different in focus, government official perspectives on introducing an emissions tax were also highly complex. For government officials, key issues were not wishing to create a generally unwanted tax that would discourage business, the need to consult all stakeholders carefully, and the possibility to levy tax based on specific emissions such as levels of SOx. Further, the actual need for any such tax was questioned, and that perhaps taxing trucks would be more effective, or that existing laws may already exist to deal with pollution. In many ways the perspectives of both groups supported our quantitative analysis, but also revealed many other significant considerations.

**4.2.3 Wider Issues**

Wider issues also emerged related to ‘temporal’; ‘procedural’ and; ‘strategic’ aspects. We had not anticipated these, nor, significantly we believe, had we encountered them in the literature. We nevertheless consider them important in any discussion of emissions tax introduction and suggest it was the open nature of the qualitative interviews that allowed them to emerge. Regarding ‘temporal’ issues, port operators noted there were technological possibilities to be more environmental, such as new engines or ‘green’ environmental paint, but these were currently expensive. One other, ‘temporal’ related point noted by one operator was their perspective that, “*basically, it is too late to conduct green port in Taiwan,*” and even if emissions could be reduced, this would still “*increase the cost burden for shipping company.*”

‘Procedurally’ there was a tension between operators feeling that it was the government that needed to introduce any policies, but that equally, if the policy was introduced by non-experts it would not be accepted by port operators, as *“some consultants are not practical workers and their thinking is theoretical… this creates a problem, because if operators think the target is difficult to achieve, they will give up and not do it at all.”* Other key procedural issues were those of shore power and fuel regulation. Both issues were highlighted, but there was disagreement with regard to whether they were viable at this time, or ever.

‘Strategically’, other parts of the logistical chain were highlighted, one government official felt pollution needed to be controlled at source, for example, by stopping ships dumping waste before they reached port. Another official felt a ‘green port’ may be more effectively achieved through the different target of regulating road transport, noting that *“basically, ship emissions at port constitute just one part of total pollution”* Thus, for both port officials and government workers, the wider issues of incoming technologies, the need for consultation with experts, other areas such as fuel regulation and shore power, and wider issues of where to actually target the source of pollution were important.

These issues, and the perspectives above, help add to and contextualize our previous quantitative data and also the data of others. We believe they are factors that are also crucial to consider and perhaps be incorporated in any calculations for an emissions tax, and certainly ones that should be considered when deciding on emissions tax policies.

1. **CONCLUSION AND DISCUSSION**

Our data shows a number of tensions and considerations for the Taiwanese authorities (and by implication for others) regarding the implementation of an emissions tax. Our quantitative analysis shows that there is a both a clear rationale for such a tax and that the costs (Pigou, 1920) are significant (US$ 3.24 per ship hour for passenger ships). We also have a context and foundation for such data from the studies made by others in the environmental costs of ships and trucks (cf*.* Berechman and Tseng, 2012) and for ships elsewhere in the world (e.g. Tzannatos 2010a; Winnes and Fridell, 2010). Our mathematical formulae and data from the three ports considered here clearly show the cost impact of such emissions and their social impacts are significant, and in this empirical respect an emissions tax is both viable and desirable. Yet, from a practical policy perspective, should an emissions tax be introduced? Our qualitative data from in-depth interviews with government officials and port operators in relation to this question revealed numerous tensions that would require discussion before any such tax were introduced.

Regarding perceptions related to introducing such a tax, there were tensions between profit and the environment, between the need to remain competitive by not introducing something punitive other ports did not have, and between using an emissions tax and drawing on other policies and approaches to control emissions. No officials or operators talked about the costs from such emissions and it is undoubtedly possible that had we mentioned these in the interviews, responses may have differed. This is something for a future study, but our not mentioning this here allowed our participants a bias-free environment to express their views. This in turn allowed us to see the tension between the factors we had included in our empirical model and a number of factors we had not. Many factors we had included were corroborated by participants: ship-type; time at berth; calculations of *NOx* and *SOx*; hour-emission volumes to name but a few. These too are factors considered in other studies (Yau et al., 2012; Chang et al, 2013; Song, 2014). Nevertheless, our participants also suggested many factors we had not considered, such as wind-speed[[10]](#footnote-10); cargo-type; tanks and storage; traffic jams; and difficulties checking the data. All these factors should arguably be included in future empirical studies.

 Our interviews also showed many wider issues, which we had not encountered in the literature, to be considered alongside any emissions tax, and which are valuable avenues for future research into port sustainability. These were of a ‘temporal’; ‘procedural’ or ‘strategic’ nature. Shore power would greatly reduce emissions, but opinions were divided on its viability in the short or long term. ‘Green’ paint and new engines were also noted to potentially help in the future. Fuel and road transport regulations were noted, but again there were tensions as to when and how they could be introduced. ‘Procedurally’ there were divisions between who should implement and decide on policies and ‘strategically’ it was clear there is a need to consider any issue in the wider transportation chain context, such as the regulating the source of pollution at sea. To introduce an emissions tax on ships at berth is all good and well, but if the main source of emissions is from truck journeys, then perhaps the focus needs to be reconsidered.

A key question in welfare economics is what should be done with these tax revenues. While this question is not within the scope of this paper, in general, revenues generated from emissions tax charges could be used for two main purposes: firstly, through air quality improvement projects via, for example, subsidies as a form of incentive for ship owners to make ships’ engines more energy-efficient. Secondly, to compensate terminal operators/workers/residents for health problems possibly related to or incurred by emissions. Regardless of how the revenue is used, we argue on the basis of the above data that the port authorities should impose these taxes on ship activity, which in turn will reduce pollution and encourage ship owners to reduce emissions. For example, air pollution (e.g. PM) affects global greenhouse emissions (Villalba and Gemechu, 2011; Chang and Chang, 2014), brings negative health impacts to residents nearby the port (Bailey and Solomon, 2004; Corbett et al. 2007; Chang et al., 2013; Chang and Chang, 2012) and damages vegetation and the built environment (McArthur and Osland, 2013). In addition, in Taiwan, most ships called at the Port of Kaohsiung (accounted for 54.17% in 2012) which is adjacent to Kaohsiung city (the second most populated municipality in Taiwan). Some residents live only 20 meters, or one street’s distance away. Any pollutants produced from the ships are likely to spread to the city and affect its residents (Berechman and Tseng, 2012). Therefore, emission mitigation (e.g. emission tax) should be emphasized to reduce the negative impacts from these emissions on residents.

Nevertheless, and in conclusion, despite all these tensions and complexities, we argue much scope exists for further study and refinement of such models with the longer term view of improving port sustainability. Arguably, any such policy needs to be implemented by more than one country so it does not adversely impact upon an individual country’s shipping industry, and it needs to be implemented after consultation with a wide-ranging body of stakeholders. Further, when a port’s tax emission policy is enacted and implemented in all ports in Taiwan, emission charging based on ship type needs to be non-discriminatory and fair. It should be related more to amounts and types of emissions and be implemented equally according to such an approach across all terminals in the port.We argue that the above empirical mathematical formulae and evidence show the importance of such a tax. However, we also argue that other elements noted in our qualitative data such as seasonality (climatic variations), wind speed, and truck emissions which were not considered here due to the research scope and available data, should be researched in future studies to help refine the accuracy of the tax. Whatever the case, a combined approach of fuller empirical mathematical calculations and greater consultation and explanation would lead to greater chances of success for any tax, and ultimately, we hope, for greater chance of it having a positive, and rationally understood, impact upon the environment. To end with the words of one of the operators that we have noted above:

*“it is a serious question. We must deal with it very carefully as it affects our country’s economic development.”*

We argue these words apply to every country’s economic development, but that to ignore the benefits that could result from the successful introduction of such a tax would be, in the long-term, more economically detrimental.

**APPENDIX 1**

**Interview Questions and ‘Spider’ Diagram**

A few preliminary questions

1. Can we tell you anything about what this is about?
2. Would you like us to tell you about our motives and aims?
3. We don’t know how much time this will take as it is very free – but we estimate approximately 1 hour.
4. We’ll record the interview as this means it is more reliable than us just taking notes – but if you’d prefer us to just take notes, please tell us. We send you the notes or the transcript of the interview for you to check and / or amend.
5. Any other questions before we start?

OK – let us tell you a bit about our approach. We have diagrams rather than questions. These may seem a bit daunting. This is not the intention. The intention is to give you, the interviewee, more control over what you talk about. You can either just talk freely about the areas in the diagram (from your experience and knowledge) and / or we can guide you, or both. Feel free to ask any questions at any time, and we may do the same too. This is not a new method, we have tried it in at least four other projects and it has been useful in helping us see more of your perspective as an interviewee.

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A few final questions

1. What did you think about doing the interview?
2. How did you feel about this method and approach?
3. Do you think it is useful what we’re doing?
4. Were you relaxed throughout?
5. Do you have any questions for us?
6. Do you feel there are any constraints placed on you that shaped your opinions for this discussion?
7. Have we missed anything?

**ACKNOWLEDGEMENTS**

Financial support for this research was provided by National Science Council, Taiwan, ROC (NSC 101-2410-H-424-015).

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1. See Tzannatos, E. (2010a), page 405, Fig 4. [↑](#footnote-ref-1)
2. See Deniz et al. (2010), page 226, Table 5. [↑](#footnote-ref-2)
3. Port of Kaohsiung, Taiwan International Port Corporation. <http://kh.twport.com.tw/en/>

Port of Keelung, Taiwan International Port Corporation. <http://kl.twport.com.tw/en/>

Port of Taichung, Taiwan International Port Corporation. <http://tc.twport.com.tw/en/>

We double check these data with Ministry of Transportation and Communication, Taiwan (<http://www.motc.gov.tw/en/index.jsp>) and confirmed the data is reliable. [↑](#footnote-ref-3)
4. Collecting ship data from the survey area is a widely adopted in many recent studies, such as Chang et al. (2013), Chang et al. (2014), Tzannatos (2010a), Hulskotte et al. (2010), McArthur and Osland (2013) and Villalba and Gemechu (2011). [↑](#footnote-ref-4)
5. Port of Kaohsiung, Taiwan International Port Corporation. <http://kh.twport.com.tw/en/>

Port of Keelung, Taiwan International Port Corporation. <http://kl.twport.com.tw/en/>

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We double check these data with Ministry of Transportation and Communication, Taiwan (<http://www.motc.gov.tw/en/index.jsp>) and confirmed the data is reliable. [↑](#footnote-ref-5)
6. EMEP/EEA air pollutant emission inventory guidebook 2013, Technical guidance to prepare national emission inventories. 1.A.3.d Navigation (Shipping). Methodology: Shippingefficiency.org-Efficiency Rating for Existing Ships. <http://www.imo.org/Pages/home.aspx> [↑](#footnote-ref-6)
7. Auxiliary engines are assumed to operate at medium speed and to use residual oil (Yang et al., 2007) since this matches current shipping practice in Taiwan. [↑](#footnote-ref-7)
8. Although ship-owners may transfer these taxes to owners of the cargo through increasing shipping fare, market price competition mechanisms would force ship-owners to make efforts (e.g., using an optimum operation model to improve cargo (un)load efficiency and reduce ship time at berth) to pay the lesser tax since the market demand expects a low shipping rate. [↑](#footnote-ref-8)
9. Currently, dedicated modern terminals with a shore power system are being constructed in Taiwanese ports. Passenger ships are viewed as a high priority to adopt shore power. When this is adopted, the pressure of high pollution tax for passenger ships will be reduced. [↑](#footnote-ref-9)
10. Strong wind speed might bring serious air pollution to land and affect coastal residents through the requirement for ships to use more engine power to counteract the force from the wind. [↑](#footnote-ref-10)