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Trade, Environmental Regulations and Industrial Mobility: An Industry-Level Study of Japan

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Abstract

This paper contributes to the small but growing body of literature which tries to explain why, despite the predictions of some theoretical studies, empirical support for the pollution haven hypothesis remains limited. We break from the previous literature, which tends to concentrate on US trade patterns, and focus on Japan. In common with Ederington *et al.*'s (2005) US study, we show that pollution haven effects are stronger and more discernible when trade occurs with developing countries, in industries with the greatest environmental costs and when the geographical *immobility* of an industry is accounted for. We also go one step further and show that our findings relate not only to environmental regulations but also to industrial regulations more generally.

JEL: F18, L51, L60, Q56, R3

Keywords: Environmental regulations, trade, agglomeration, immobility, industry

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Introduction

The potential link between the stringency of environmental regulations and international trade and investment patterns has been discussed by politicians, academics and the media for over two decades, yet such issues remain high on the international policy agenda. The recent US proposal to impose carbon tariffs on imports of carbon-intensive goods such as steel, cement, paper and glass from countries that have not taken steps to reduce their own emissions provides a case in point. India has already expressed its strong opposition to such plans, while the WTO is concerned that there may be a profusion of unilateral climate-related trade restrictions of this nature, particularly given the failure of the 2009 Copenhagen negotiations to achieve an international climate change agreement. The conventional wisdom amongst policy makers therefore suggests a clear link between regulation costs and trade flows, a position often supported by the predictions of many theoretical studies (e.g. McGuire 1982, Baumol and Oates 1988, Chichilnisky 1994). However, a sizeable empirical literature has failed to find compelling evidence to support the hypothesis that pollution intensive industries in developed economies will migrate to less regulated economies (e.g. Kalt 1988, Tobey 1990, Grossman and Krueger 1993 and Cole and Elliott 2003a).

More recent studies have therefore focused on the reasons why industries in highly regulated economies do not systematically relocate in this manner. Antweiler *et al.* (2001) argued that trade in pollution intensive industries may be subject to both pollution haven and traditional factor endowment pressures. More specifically, since pollution intensive industries are typically the most capital intensive, these different pressures may actually compete against each other and hence tend to cancel out (Antweiler *et al.* 2001, Cole and Elliott 2003b and Cole and Elliott 2005). In addition, Ederington and Minier (2003) and Levinson and Taylor (2008) raise the possibility that environmental regulations may act as secondary trade barriers i.e. a means of protecting domestic industry. If this is the case, then the stringency of regulations may be a function of trade as well as trade being a function of regulations. When treated as an endogenous variable, both Levinson and Taylor (2008) and Ederington and Minier (2003) find that US environmental regulations do influence US trade patterns.

Ederington *et al.* (2005) suggest that there may be three reasons for the lack of evidence in support of the pollution haven hypothesis. Firstly, since most trade occurs between developed economies which have similar levels of regulatory stringency, an analysis of aggregate trade flows is unlikely to detect the impact of regulations on patterns of trade between high and low income economies. Second, for most industries environmental costs form a very small proportion of total costs. As such, the pressure to physically relocate may be relatively minor for many industries. However, there are a small subset of industries for whom such costs may be more considerable and who may therefore be subject to pollution haven pressures. Finally, Ederington *et al.* (2005) argue that some industries are more footloose than others. Those that experience high transport costs, high plant fixed costs or benefit from agglomeration economies may tend to be less geographically mobile.

Thus, by mixing industries that are both relatively immobile and relatively footloose, previous analyses may have failed to detect pollution haven pressures amongst the footloose industries. Using US industry-level data for the period 1978-92, Ederington *et al.* find some evidence to support each of these three points. [1] In a theoretical study, Zeng and Zhao (2009) focus on one aspect of industry immobility – the existence of agglomeration economies – and illustrate how such economies can negate pollution haven pressures, particularly if differences in regulatory stringency between 'North' and 'South' are relatively small. Finally, Wagner and Timmins (2009)

[1] However, Levinson (2009) concludes that the shifting of pollution intensive activities overseas has had only a minor effect on US air quality levels which have, in the main, benefitted from changing technology.

illustrate the importance of agglomeration economies to German FDI flows from pollution intensive industries and show that pollution haven effects are detectable when such agglomeration economies are controlled for.

The previous literature therefore suggests that regulations may influence certain firms' relocation patterns in a manner consistent with the pollution haven hypothesis but many previous studies were failing to detect this by not targeting the most relevant industries or trade with the most relevant economies. However, to date, the only compelling evidence for this assertion, in the context of trade flows, is provided by Ederington *et al.* (2005) for US industries. What remains unknown therefore is whether this finding is specific to the US, particularly given its close trade links and common border with Mexico, or whether it would be common to all major industrial economies. Secondly, the dataset used by Ederington *et al.* ends in 1992 and hence we are unclear whether such findings may be specific to the period under consideration, primarily the 1980s, or whether such pressures are detectable more recently.

The aim of the present paper is therefore to focus on a major industrial economy other than the US, namely Japan, and to assess whether pollution haven pressures on trade flows are detectable if we focus on the more appropriate trading partners and more appropriate industries in the manner suggested by Ederington *et al.* In addition to examining the stringency of environmental regulations, we go beyond the analysis of Ederington *et al.* by also considering a measure of general industrial regulations. This allows us to assess whether Japanese trade flows are influenced by industrial and labour regulations alongside environmental regulations.

Japan represents an ideal country for a study of this type. The data we analyse are for the years 1989-2003. This was a period of significant change in both trade and the regulatory framework in Japan. From the early 1990s Japan entered a period of relative economic stagnation following the bursting of the asset bubble. This was a period when Japan had to undertake structural reforms and take measures to revitalise domestic industry as well as dealing with deflation and non-performing loans.[2] Until the 1980s, the Japanese economy grew by producing domestically competitive products and discovering new markets abroad. The appreciation of the Yen in the mid-1980s forced many firms to shift production to East Asia. These production networks are now an important part of the Japanese economy.

Even though the 1990s were a period of stagnation, Japan continued to experience a steady increase in imports and exports and managed to maintain a surplus throughout this period. Concern remains, however, that expansion abroad and a maturing domestic market led to a contraction of Japan's industrial base. Outward foreign direct investment (FDI) remained high during this period particularly to the US and East Asian regions. In 2002 17.7% and 35.3% of imports were from the US and the EU, respectively, while 10.9% of exports went to the US and 38% of exports to the EU. China was responsible for 5.1% and 4.5% of exports and imports respectively. The remaining share consists of considerable trade with the other developing countries including significant oil imports from the Middle East (JETRO 2003). In terms of trade openness (imports plus exports divided by GDP), Japan presents a remarkably similar picture to the US with a value of 22.07 in 2003 compared to 23.39 for the US. The UK in contrast is 55.62 and 47.38 for China (Penn World Tables 6.2).

While the Japanese economy has historically been highly regulated, a process of deregulation began in the late 1990s in an attempt to increase Japanese competitiveness. This process is ongoing although Japan would still appear to be a highly regulated economy particularly in areas

[2] In the 1990s Japan implemented significant tax cuts aimed at revitalising the domestic economy. Ares that the reforms were targeted at included research and development investment, capital investment and financial support for small and medium sized enterprises.

such as finance, telecommunications and transport. Other areas such as health and safety and environmental protection have generally seen increased regulation in recent years.

With regard to environmental regulation, following a series of environmental disasters in the 1950s and 1960s Japan is often considered to be at the forefront of the introduction and implementation of environmental policy. In 1970 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. Finally, in 2001 a Ministry of the Environment was set up, 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 cleanest environments earlier than most OECD countries (Sumikura (1998 pp. 255) and demonstrated that a good environmental reputation is not only good for the environment but is also a valuable economic and cultural asset.

The remainder of the paper is organised as follows. Section 2 describes the methodology and the results are presented in Section 3. Section 4 concludes.

Methodology

In common with the previous literature on trade and the pollution haven hypothesis, we test the impact of regulations on trade patterns using industry-level data for the manufacturing sector. Specifically, we begin by estimating, using fixed effects, the determinants of industry-level net imports for 41 Japanese manufacturing sectors over the period 1989-2003, in accordance with equation (1) below;

$$M_{it} = a_i + \lambda_t + \beta_1 KL_{it} + \beta_2 T_{it} + \beta_3 R_{it} + \varepsilon_{it} \qquad (1)$$

where M_{it} denotes net imports in industry *i* and year *t*, defined as imports minus exports divided by industry value added.[3] *KL* denotes the capital-labour ratio, defined as physical capital stock per worker; *T* represents tariffs, measured as tariff revenues as a share of imports in each industry; a_i is an industry specific intercept and λ_t is a year specific dummy.

R denotes regulations, for which we have two measures. The first is a measure of environmental regulation costs which we denote as *ENVREG*. The disposal of industrial waste in Japan is subject to stringent regulation and can prove costly to firms. *ENVREG* measures the costs incurred by industries when disposing of industrial waste as they are required to by law, where waste includes scrap iron and steel, paper, glass, oil waste, polluted mud/sludge, acid, plastics, dust and rubble. Note that these costs do not include the cost of abating standard local air pollutants such as sulphur dioxide but are nevertheless costs incurred by firms when complying with Japanese environmental regulations. As such they provide an ideal measure of regulation costs for our study. Waste costs are expressed per unit of output. Industry-level environmental regulation cost data such as these are reported for relatively few countries with the US leading the field in terms of data availability. It is for this reason that the emphasis of industry-level pollution haven studies is firmly on the US economy with studies of other countries tending to use proxies for regulation costs such as pollution intensity or survey results (Xing and Kolstad 2002 and Wagner and Timmins 2009).

[3]Data are from the JIP dataset produced by the Japanese Research Institute of Economy, Trade and Industry (RIETI). Table A1 in the Appendix provides definitions and sources for all variables.

Our second measure of regulation, *INDREG*, is a measure of the coverage of general regulations within an industry. This measure, constructed by Japan's Research Institute of Economy, Trade and Industry (RIETI) as part of the JIP database, is calculated by examining 303 four-digit sectors within 110 three-digit sectors within the 41 two-digit manufacturing sectors in our sample and assessing whether they are subject to approximately 3,000 industrial regulations within Japan.[4] If all four-digit sectors within a three-digit sector are regulated by one of more of these regulations then the three-digit sector is classed as being 'regulated'. *INDREG* is constructed by aggregating the value added of regulated three-digit sectors and expressing it as a share of value added within the two-digit sector as a whole. For instance, if an industry has a *INDREG* value of 50 this implies that those three-digit industries that we class as being 'regulated' (because *all* four-digit sectors within them are subject to at least one of the 3,000 regulations) contribute 50% to the two-digit industry's value added. Equation 2 *INDREG*;

$$INDREG_{it} = \frac{\sum_{Rj=1}^{n} VA_{Rjt}}{VA_{it}} \qquad (2)$$

Where *i* refers to a two-digit industry, *t* refers to year, *VA* refers to value added and *Rj* denotes a regulated three-digit industry. The regulations considered within the *INDREG* measure cover all aspects of activity, and relate to finance, labour, trade and health and safety, for example. Also included are environmental regulations implying a degree of overlap between our two regulation measures. Unfortunately, we are not able to remove the environmental regulations from *INDREG*.

[4] The industrial classification used (JIP) is specific to Japan and does not conform precisely to international classifications such as International Standard Industrial Classification (ISIC) and Standard International Trade Classification (SITC).

Appendix Table A3 provides the 10 most regulated industries according to our two regulation measures. With regard to *ENVREG*, many of these industries would confirm to prior expectations and include Basic Chemicals, Chemical Products, Rubber, Paper Production and Plastic Products. These industries are often shown to be amongst the most pollution intensive in the US and the UK for whom industry level emissions data are available (see for example Cole *et al.* 2005). With regard to our general measure of industrial regulations, *INDREG*, we see a variety of different industries in the top 10, including high-tech electrical equipment, machinery production of various forms and chemical industries. This mixture of industries would seem to be influenced by a wide range of different regulations although health and safety regulations would seem to be a possible common denominator.

Following Ederington *et al.* (2005), our aim is to test (i) whether pollution haven effects are discernible if we focus on trade with developing regions rather than aggregate trade flows (ii) whether such effects are discernible if take into account the fact that some firms are more footloose than others and (iii) whether pollution haven effects can be detected within industries with larger regulation costs. In addition, for each of these hypotheses we test the effect of environmental regulations and general regulations on trade separately.

To test point (i) we estimate separately the determinants of industry-level total net imports from the world as a whole; net imports from the developing world; and net imports from China[5]. We would expect the impact of regulations on net imports to be greater in terms of magnitude, and perhaps statistical significance, for net imports with the developing world and China.[6]

[5] Japan undertakes significant outsourcing to China and since 2004 China has become the largest recipient of Japanese FDI within Asia (Japan External Trade Organization). China has therefore become a significant source of intermediate goods for the Japanese economy.

[6] In common with the existing pollution haven literature, we are only able to estimate net imports as a function of *domestic* environmental regulations as opposed to those of the trading partner. We are therefore assuming that such industry-specific domestic regulations provide a 'push-factor' but cannot explicitly measure the 'pull factor' provided

Regarding point (ii) we wish to examine whether certain industries are less responsive to environmental regulations, and industrial regulations in general, because they are inherently less mobile. Similarly, we might expect more footloose industries to show greater sensitivity to changes in regulation costs. We capture an industry's mobility in two ways. First we use a measure of average transport costs within an industry which we denote as *TRANS*. The argument here is that industries with large transport costs cannot locate far from their customers and hence will be less inclined to relocate in the face of regulation costs. Using HS 9 digit data on Japanese exports we calculate the unit value of each sector (value to weight ratio), defined as 1000 Yen of output per Kg. We then calculate the average unit value within each of our 41 industries. For ease of interpretation we take the reciprocal of the unit value to obtain a measure of immobility in the form of a weight to value ratio (Kg per 1000 Yen of value). We expect regulation costs to have a smaller effect on net imports in industries with large transport costs.[7]

The second measure of immobility captures agglomeration economies within an industry and is denoted as *AGGLOM*. If an industry is benefiting from such economies it will be reluctant to relocate to avoid regulations unless the benefits of relocation (in terms of regulation costs avoided) exceed the lost agglomeration economies. In short, we would expect regulation costs to have a smaller impact on net imports in industries with larger agglomeration economies. To measure agglomeration economies we used a Gini index capturing the distribution of firms

by overseas regulations. Nevertheless, we expect the impact of Japanese regulations to be greater on net imports from China and the developing world since anecdotal evidence suggests that Japanese regulations are more stringent than those in China and the developing world.

[7] We acknowledge that, when considering transport costs, firms are concerned with both the weight of the product and the distance it has to be shipped. Nevertheless, we believe our weight based measure provides a good indication of the magnitude of transport costs that an firm or industry is likely to incur.

across 47 prefectures for each industry. The greater the Gini index the greater the unevenness (or inequality) of the distribution and hence the greater the agglomeration of firms.[8]

To assess the extent to which an industry's immobility influences the impact of regulations on trade, we interact our measures of regulations with our measures of immobility and include them in equation (1). We predict the coefficient on such interactions will be negative and statistically significant, implying that the overall effect of regulations on net imports is lower the greater the degree of immobility.

Finally, regarding point (iii) above, we wish to examine whether regulation costs have little overall impact on net imports because they tend to form only a small proportion of total costs in the majority of industries. We test this in two ways. First, we interact our two regulation measures with the average level of regulation within the industry over our sample period (i.e. we interact *ENVREG* with average *ENVREG* and we interact *INDREG* with average *INDREG*). A positive, statistically significant, coefficient on such an interaction would indicate that an increase in regulation costs has a greater impact on net imports the higher the average level of regulation costs. Second, we create a dummy variable for the 5 industries with the greatest level of *INDREG* and *ENVREG*. We then interact these dummy variables with the appropriate regulation measure (*INDREG* and *ENVREG*). These interaction variables therefore allow us to test whether the level of regulations in the most highly regulated industries has an impact on net imports over and above the impact of regulations across all industries.[9]

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[8] Appendix A4 provides the 10 most immobile (i.e. least footloose) industries according to our measure of agglomeration economies (*AGGLOM*) and transport costs (*TRANS*). Agglomeration effects in Japan could be offset if new industry "agglomerations" develop in other countries. The generation of industrial clusters is increasingly being used as part of industrial policy and a means of attracting FDI to a region or country.

[9] A third way of addressing this point would be to include a squared term for *INDREG* and *ENVREG*. In unreported estimations we did include such terms and results were highly consistent with those estimated using interaction terms.

Results

Tables 1-3 provide our estimation results. Table 1 reports the estimation of our basic model, as set out in equation (1), where measures of immobility are omitted. Columns 1-3 provide the results for total net imports (from the world), net imports from the non-OECD and net imports from China, respectively, using our waste costs measure of regulation costs. Columns 4-6 do the same but replace waste costs with our measure of general industrial regulations, while columns 7-9 include both measures of regulations.

[Table 1 about here]

With regard to our regulation variables we see that the coefficients on both measures are positive and statistically significant for net imports from all three geographical groupings. To provide some insight into the magnitude of the regulation effects, Table 4 provides elasticities calculated at the means of the relevant variables for the full specification models 7 to 9. We find that a 1% increase in *ENVREG* would increase total net imports by 0.13%, non-OECD net imports by 0.14% and Chinese net imports by 1.28%. Comparable figures for a 1% increase in *INDREG* are 1.15% for total net imports, 1.41% for non-OECD net imports and 2.54% for Chinese net imports. In common with the findings of Ederington *et al.* (2005), we therefore also find the magnitude of the impact of regulations to be greater in the context of trade with developing regions. However, in contrast to Ederington *et al.*'s US findings, we do still find Japanese regulations to have a statistically significant effect on net imports from the world as a whole.

As expected, the coefficient on the capital labour ratio is negative and generally statistically significant, particularly for net imports from the non-OECD. The coefficients on tariffs are negative for total net imports and net imports from the non-OECD but positive for net imports from China. However, in each case they are statistically insignificant.[10]

Table 2 reports estimates of an extended model where we include *AGGLOM*, our measure of agglomeration economies intended to capture an industry's immobility. Columns 1-3 include *AGGLOM*, *ENVREG* and an interaction of the two, again for our three geographical groupings. Columns 4-6 replace waste costs with our measure of general industrial regulations, including an interaction with *AGGLOM*, and columns 7-9 include both measures of regulations and both interactions.

[Table 2 about here]

The coefficient on the capital labour ratio remains negative throughout and now displays greater statistical significance. The sign and (lack of) significance of tariffs is similar to that in Table 1.[11] Turning to *AGGLOM*, our measure of agglomeration economies, we see that it is generally a negative determinant of net imports and is statistically significant for China. This suggests that industries that benefit from agglomeration economies are likely to experience lower net imports from China, as we might expect. However, it is the interactions with *ENVREG* and *INDREG* that interest us most. We can see that the coefficient on *AGGLOM* interacted with *ENVREG*

[10] Our tariff variable is an aggregation of all tariff revenues from all countries and does not take account of preferential tariffs or regional trade agreements. Such a measure is consistent with previous studies (for example Ederington et al. 2005). The lack of statistical significance may reflect the relatively high level of industry aggregation in this study which may be preventing tariff revenues from having a meaningful impact on net imports. In addition, our industry fixed effects may be partly capturing the effects of tariffs due to the relative lack of temporal variance within this variable.

[11] In unreported estimations we interacted tariffs with both *AGGLOM* and *TRANS* but the coefficients on these interactions were not statistically significant.

is negative in all models and statistically significant for net imports from the OECD. Similarly, the coefficient on *AGGLOM* interacted with *INDREG* is also negative but displays even greater statistical significance. These results therefore indicate that while regulations costs (however measured) increase net imports, this effect is reduced in industries that are relatively immobile.

In terms of elasticities as reported in Table 4, we find that a 1% increase in *ENVREG* will increase total net imports by 0.11%, non-OECD net imports by 0.16% and Chinese net imports by 1.18%, at the sample mean level of *AGGLOM*. However, for a relatively immobile industry at the top 25th percentile of *AGGLOM*, a 1% increase in *ENVREG* has a smaller impact, increasing total net imports by 0.07%, non-OECD net imports by 0.10% and Chinese net imports by 1.09%.

With regard to our second measure of regulations, a 1% increase in *INDREG* will increase total net imports by 1.10%, non-OECD imports by 1.21% and Chinese net imports by 2.20%, at the mean level of *AGGLOM*. For an industry at the top 25th percentile of *AGGLOM* we again find regulations to have a smaller effect. At this level of *AGGLOM* a 1% increase in *INDREG* will increase total net imports by 0.93%, non-OECD net imports by 1.01% and Chinese net imports by 1.23%.

Table 3 is equivalent to Table 2 but *AGGLOM* has been replaced as a measure of immobility with a measure of transport costs (*TRANS*). On its own we can see that the coefficient on *TRANS* is generally negative and statistically significant in four of the nine models, notably in the models of trade with China and the non-OECD. This suggests that industries with greater transport costs are likely to experience lower net imports from China and the developing world, perhaps due to their immobility. Turning to the interactions between *TRANS* and our two measures of regulations, we can see that the coefficient on *TRANS* interacted with *ENVREG* is insignificant throughout and of mixed sign. However, the coefficients on *TRANS* interacted with *INDREG* are negative and consistently significant in all models.

[tTable 3 about here]

From Table 4, a 1% increase in *INDREG* will increase total net imports by 0.26%, non-OECD net imports by 0.29% and Chinese net imports by 0.30% at the mean level of *TRANS*. As in Table 2, the effects of *INDREG* on net imports can be seen to be smaller in the presence of immobility, here measured in the form of transport costs. In a relatively immobile industry, where *TRANS* is at the top 25th percentile, a 1% increase in *INDREG* will increase total net imports by 0.06%, non-OECD net imports by 0.17% and Chinese net imports by 0.18%. [12]

Tables 5 and 6 provide the results from testing our third hypothesis, whether the effect of regulations on net imports is more discernible in high regulation cost industries. For reasons of space we concentrate on net imports from the non-OECD and from China. In Table 5, columns 1-4 include our measure of *ENVREG* interacted with the average level of *ENVREG* within each industry over the sample period, with columns 1 and 2 including *AGGLOM* as the measure of immobility and columns 3 and 4 including *TRANS* as the measure of immobility. Columns 5-8 instead include *ENVREG* interacted with a dummy variable equal to one for the five industries with the greatest average level of ENVREG. [13] Columns 5 and 6 include *AGGLOM*, columns 7 and 8 include *TRANS*. Table 6 replicates Table 5 using *INDREG* instead of *ENVREG*.

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[12] We also estimate models in which we include both *TRANS* and *AGGLOM* together with their interactions with *INDREG* and *ENVREG*. The sign and significance of these variables was almost identical to those in Tables 1-3 and hence for reasons of space we do not report these results.

[13] In unreported sensitivity analyses we also tested a dummy capturing the ten industries with the greatest average level of *ENVREG*. Results were almost identical.

[Table 5 about here]

[Table 6 about here]

With regard to Table 5, we can see that the coefficient on *ENVREG* interacted with average *ENVREG* over the sample period is positive in three of the four models and significant in one of those. In the other model it is negative and statistically insignificant. The positive coefficients imply that *ENVREG* has a greater effect on net imports the greater the level of average *ENVREG* within an industry. However, the limited statistical significance reduces the strength of this finding. Turning to *ENVREG* interacted with a high *ENVREG* dummy variable in columns 5-8 we can see that the coefficient on this interaction variable is positive in all four models and statistically significant in two of these. This therefore suggests that in the 5 'dirtiest' industries *ENVREGs* have an impact on net imports over and above the average impact across all industries (as captured by the coefficient on the *ENVREG* variable). Table 6 provides very similar conclusions for *INDREG*. For both *INDREG* interacted with average *INDREG* and *INDREG* interacted with a high *INDREG* dummy there are four positive, significant coefficients with the remainder insignificant and of mixed sign. We have therefore found some evidence that *INDREG* has a greater effect on net imports the greater the level of *INDREG* within an industry.

In contrast to this finding, Ederington et al. find that regulation costs interacted with average regulation costs is actually a negative statistically significant determinant of net imports. This seemingly counterintuitive result suggests that environmental costs have a smaller impact in pollution intensive industries. However, once the immobility variables are included in the equation regulation costs interacted with average regulation costs becomes statistically insignificant. These two findings would seem to indicate that high regulation cost (pollution intensive) industries are also less footloose. For Japan, we find that *ENVREG*ave* and

*INDREG*ave* is statistically significant, in some models, even once immobility measures are included suggesting that regulation costs have a greater impact on net imports in high regulation cost industries. One possible reason for this slight difference in our findings relative to those of Ederington et al. may be that the correlation between immobility and regulation costs may be lower in Japan than the US.[14]

Conclusions

This paper finds environmental and industrial regulations to be statistically significant determinants of Japanese net imports from the rest of the world, from the non-OECD countries and from China. We also find the magnitude of the impact of regulations on trade flows to be greatest on trade flows with the developing world.

In line with Ederington *et al.* (2005), we find that the degree to which an industry is footloose can have a major influence on the extent to which regulations influence its net imports. Using agglomeration economies and transport costs to capture an industry's immobility, we find that the greater the level of immobility within an industry the smaller the effect of regulations on net imports. Finally, we find that the impact of regulations on net imports is greater the higher the average regulation costs are within the industry.

In common with Ederington *et al.* (2005) and Cole and Elliott (2005) this paper therefore supports the argument that while pollution haven effects may not be experienced by all

[14] The Spearman correlation coefficient between *ENVREG* and *AGGLOM* is 0.083 (p-value 0.027) and between *ENVREG* and *TRANS* is 0.16 (p-value 0.000). Ederington et al. do not report such correlations for the US.

industries, such effects are greatest, and most detectable, when trade occurs between developed and developing economies and in relatively mobile industries with high regulations costs.

In terms of the policy implications of our findings, Japan has acknowledged that in order to maintain its competitive position it needs to maintain a leading presence in R&D, to build on existing agglomerations and to foster new clusters and to attract the best capital and minds from around the world. Our study suggests that an additional benefit from agglomeration is that it can yield benefits sufficient to offset relatively high environmental costs thereby protecting jobs in what may otherwise have been vulnerable industries.

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APPENDIX 1. Data Definitions and Sources

Variable	Definition	Source
Total net M	Net imports from the world as a share of value added (in million Yen)	JIP dataset from the Japanese Research Institute of Economy, Trade and Industry (RIETI)
Non-OECD net M	Net imports from the non-OECD as a share of value added (in million Yen)	JIP dataset from RIETI
Chinese net M	Net imports from China as a share of value added (in million Yen)	JIP dataset from RIETI
K/L	Physical capital stock per worker (in million Yen)	JIP dataset from RIETI
TARIFF	Tariff revenues as a share of imports	JIP dataset from RIETI
ENVREG	Waste disposal costs per unit of output	JIP dataset from RIETI
INDREG	A measure of the coeverage of regulations within an industry	JIP dataset from RIETI
AGGLOM	Agglomeration economies measured as a Gini index capturing the distribution of firms across 47 prefectures	Japanese Manufacturing Census
TRANS	Transport costs proxied using the unit value of each industry (1000 Yen per kg).	Custom data from the Japanese Ministry of Finance

Note. All variables are measured at the industry-level.

APPENDIX 2. Summary Statistics

	Mean	Standard Deviation	Min	Max
Total net M	-52.12	199.76	-847.52	1199.84
Non-OECD netM	-36.33	104.57	-329.05	496.38
Chinese net M	3.46	22.44	-109.19	157.57
K/L	23.92	27.85	1.32	201.54
TARIFF	4.13	2.03	0	10.83
ENVREG	0.52	1.32	0	7.94
INDREG	10.87	24.35	0	100
AGGLOM	0.55	0.094	0.30	0.79
TRANS	12.86	10.93	0	69.77

APPENDIX 3. The Most Regulated Japanese Industries

Most regulated industries (*ENVREG*)	Most regulated Industries (*INDREG*)
Inorganic basic chemicals	TV and radio receivers, sound and video equipment
Rubber	Chemical fertilizers
Furniture	Other transport machinery
Final chemical products	Electrical machinery
Paper production	Other electrical machinery
Publishing	Precision Machinery
Other manufacturing products	Inorganic basic chemicals
TV and radio receivers, sound and video equipment	Other manufacturing products
Leather and leather products	Final chemical products
Plastic products	Non-ferrous metal products

Source: Authors' own calculations

APPENDIX 4. The Most Immobile Japanese Industries

Most Immobile industries (*AGGLOM*)	Most Immobile Industries (*TRANS*)
Leather and leather products	Chemical fertilizers
Rubber	Motor vehicles
Precision machinery	Cement and cement products
Non-ferrous metal refining	Other iron and steel
Non-ferrous metal products	Chemical fibre and textiles
Motor vehicle components	Pulp and paper
Other transport machinery	Motor vehicle components
Motor vehicles	Metal products for construction
Publishing	Pig iron and steel
Office and computing machinery	Furniture

Source: Authors' own calculations

Table 1. Basic models, without interactions.

	(1) Total	(2) Non-OECD	(3) China	(4) Total	(5) Non-0ECD	(6) China	(7) Total	(8) Non-OECD	(9) China
K/L	-0.23	-0.25	-0.074	-0.35*	-0.31**	-0.085	-0.37*	-0.32**	-0.095
	(0.9)	(1.6)	(1.1)	(1.7)	(2.2)	(1.3)	(1.7)	(2.3)	(1.5)
TARIFF	-2.88	-0.26	0.70	-3.64	-0.60	0.64	-3.74	-0.68	0.57
	(1.0)	(0.2)	(1.5)	(1.2)	(0.4)	(1.4)	(1.2)	(0.5)	(1.3)
ENVREG	10.88***	9.07***	8.20***				13.00***	10.10***	8.51***
	(3.1)	(3.7)	(4.6)				(3.6)	(4.2)	(4.9)
INDREG				5.37***	2.59***	0.71***	5.53***	4.72***	0.81***
				(5.5)	(3.8)	(4.0)	(5.7)	(4.0)	(4.8)
Constant	-56.59***	-38.86***	-8.84***	-103.57***	-59.79***	-11.88***	-111.14***	-65.67***	-16.84***
	(4.0)	(6.1)	(4.1)	(6.3)	(6.6)	(4.6)	(6.7)	(7.1)	(6.4)
Observations	579	579	579	579	579	579	579	579	579
R-squared	0.081	0.064	0.073	0.050	0.045	0.11	0.090	0.080	0.13

Robust t statistics in parentheses
* significant at 10%; ** significant at 5%; *** significant at 1%

Industry and year effects included.

Table 2. Using Agglomeration Economies (*AGGLOM*) as a measure of immobility.

	(1) Total	(2) Non-OECD	(3) China	(4) Total	(5) Non-OECD	(6) China	(7) Total	(8) Non-OECD	(9) China
K/L	-0.42*	-0.25	-0.14**	-0.64***	-0.40***	-0.20***	-0.63***	-0.39***	-0.19***
	(1.7)	(1.6)	(2.3)	(3.2)	(3.5)	(3.4)	(3.1)	(3.4)	(3.2)
TARIFF	-3.30	-0.14	0.53	-3.60	0.052	0.64	-3.53	0.14	0.67
	(1.1)	(0.1)	(1.2)	(1.1)	(0.0)	(1.6)	(1.1)	(0.1)	(1.6)
AGGLOM	-400.22	60.58	-145.40**	-330.04	145.90	-135.61**	-234.77	248.40	-77.55
	(0.8)	(0.4)	(2.3)	(0.6)	(0.9)	(2.0)	(0.4)	(1.5)	(1.2)
ENVREG	34.35	44.37**	11.62				40.73	47.73**	12.66
	(1.0)	(2.4)	(1.2)				(1.2)	(2.4)	(1.3)
*AGGLOM*ENVREG*	-48.10	-63.80**	-8.12				-54.32	-66.25**	-8.80
	(0.9)	(2.0)	(0.5)				(1.0)	(2.0)	(0.5)
INDREG				11.82***	9.63***	3.19***	12.19***	10.01***	3.44***
				(3.2)	(6.1)	(4.7)	(3.2)	(6.4)	(5.3)
*AGGLOM*INDREG*				-12.15*	-13.41***	-4.67***	-12.57*	-10.84***	-4.98***
				(1.7)	(4.3)	(3.8)	(1.7)	(4.5)	(4.2)
Constant	175.72	-72.67	75.38**	94.94	-133.22	69.43*	35.08	-197.30**	31.96
	(0.6)	(0.8)	(2.1)	(0.3)	(1.5)	(1.8)	(0.1)	(2.1)	(0.8)
Observations	579	579	579	579	579	579	579	579	579
R-squared	0.10	0.11	0.14	0.060	0.050	0.13	0.11	0.14	0.18

Robust t statistics in parentheses
* significant at 10%; ** significant at 5%; *** significant at 1%

Industry and year effects included.

Table 3. Using transport costs (*TRANS*) as a measure of immobility.

	(1) Total	(2) Non-OECD	(3) China	(4) Total	(5) Non-OECD	(6) China	(7) Total	(8) Non-OECD	(9) China
K/L	-0.25	-0.48***	-0.20***	-0.38**	-0.55***	-0.22***	-0.39**	-0.55***	-0.22***
	(1.1)	(3.1)	(3.3)	(2.1)	(4.5)	(4.1)	(2.1)	(4.5)	(4.1)
TARIFF	-2.95	0.39	0.85*	-2.59	0.26	1.05**	-2.75	0.12	0.93**
	(1.0)	(0.0)	(1.8)	(0.9)	(0.2)	(2.2)	(1.0)	(0.1)	(2.0)
TRANS	-0.37	-4.60***	-2.54***	4.78	-1.94	-1.35***	4.64	-2.06	-1.44***
	(0.1)	(3.6)	(5.0)	(1.3)	(1.3)	(3.7)	(1.3)	(1.3)	(4.0)
ENVREG	10.94***	10.41***	8.30***				12.40***	11.14***	8.60***
	(2.7)	(3.5)	(3.8)				(2.8)	(3.5)	(3.7)
*TRANS*ENVREG*	-0.18	0.016	0.0019				0.11	0.16	0.069
	(0.6)	(0.1)	(0.0)				(0.5)	(1.3)	(0.7)
INDREG				3.46***	1.84**	0.41*	3.56***	1.91**	0.47**
				(3.3)	(2.3)	(1.8)	(3.3)	(2.4)	(2.1)
*TRANS*INDREG*				-0.19***	-0.095***	-0.041***	-0.18***	-0.073***	-0.029***
				(4.8)	(5.0)	(7.7)	(4.7)	(4.9)	(7.3)
Constant	-62.04	-94.33***	-39.27***	-53.26	-88.49***	-30.57***	-60.82	-94.81***	-35.87***
	(1.4)	(5.7)	(6.0)	(1.0)	(4.2)	(6.0)	(1.2)	(4.5)	(7.0)
Observations	579	579	579	579	579	579	579	579	579
R-squared	0.14	0.19	0.22	0.052	0.10	0.20	0.15	0.20	0.27

Robust t statistics in parentheses
* significant at 10%; ** significant at 5%; *** significant at 1%

Industry and year effects included.

Table 4. Estimated Elasticities for ENVREG and INDREG from Tables 1, 2 and 3

	Total	Non-OECD	China
ENVREG (from Table 1)	0.13	0.14	1.28
ENVREG (from Table 2)	0.11	0.16	1.18
ENVREG (from Table 3)	0.14	0.19	1.43
INDREG (from Table 1)	1.15	1.41	2.54
INDREG (from Table 2)	1.10	1.21	2.20
INDREG (from Table 3)	0.26	0.29	0.30

Estimated elasticities are from the full specification in each Table (models 7, 8 and 9)

Table 5. Including *ENVREG* interacted with average industry waste costs and a high waste cost dummy.

	(1) Non-OECD	(2) China	(3) Non-OECD	(4) China	(5) Non-OECD	(6) China	(7) Non-OECD	(8) China
K/L	-0.25	-0.14**	-0.46***	-0.19***	-0.23	-0.14**	-0.48***	-0.20***
	(1.6)	(2.3)	(2.9)	(3.2)	(1.5)	(2.2)	(3.1)	(3.3)
TARIFF	-0.14	0.52	-0.012	0.83*	-0.37	0.46	0.080	0.92*
	(0.1)	(1.2)	(0.0)	(1.8)	(0.3)	(1.0)	(0.1)	(1.9)
ENVREG	45.42**	7.02	29.01***	12.46***	90.43***	26.54*	9.07***	5.90***
	(2.2)	(0.7)	(2.9)	(2.7)	(3.4)	(1.9)	(3.3)	(3.4)
*ENVREG*ave*	-0.11	0.47	0.97**	0.89				
	(0.2)	(1.4)	(2.2)	(1.0)				
*ENVREG*dum*					40.70**	13.18	3.87	6.83***
					(2.3)	(1.4)	(1.2)	(3.5)
AGGLOM	60.32	-144.28**			82.84	-138.19**		
	(0.4)	(2.3)			(0.5)	(2.2)		
*AGGLOM*ENVREG*	-65.14*	-2.14			-76.04**	-12.09		
	(1.9)	(0.1)			(2.3)	(0.7)		
TRANS			-4.47***	-2.51***			-4.66***	-2.66***
			(3.6)	(5.1)			(3.7)	(5.0)
*TRANS*ENVREG*			33.63	5.73			150.85	239.19**
			(0.3)	(0.1)			(0.7)	(2.1)
Constant	-72.47	74.48**	-95.00***	-39.42***	-87.52	70.57*	-95.37***	-41.10***
	(0.8)	(2.0)	(5.9)	(6.1)	(1.0)	(1.9)	(5.8)	(6.0)
Observations	579	579	579	579	579	579	579	579
R-squared	0.050	0.14	0.10	0.22	0.060	0.14	0.10	0.21

Robust t statistics in parentheses
* significant at 10%; ** significant at 5%; *** significant at 1%

Industry and year effects included. *ENVREG*ave* is *ENVREG* multiplied by average *ENVREG* within each industry over time. *ENVREG*dum* is *ENVREG* interacted with a dummy =1 for the 5 industries with the highest levels of *ENVREG*.

Table 6. Including *INDREG* interacted with average *INDREG* and a high *INDREG* dummy.

	(1) Non-OECD	(2) China	(3) Non-OECD	(4) China	(5) Non-OECD	(6) China	(7) Non-OECD	(8) China
K/L	-0.47***	-0.25***	-0.56***	-0.23***	-0.46***	-0.22***	-0.57***	-0.27***
	(4.7)	(4.7)	(4.8)	(4.5)	(4.0)	(4.4)	(4.4)	(5.2)
TARIFF	-0.98	60.43	22.79	99.80**	-39.04	43.81	35.74	66.00*
	(0.0)	(1.5)	(0.2)	(2.1)	(0.3)	(1.3)	(0.3)	(1.9)
INDREG	9.33***	3.00***	1.85**	0.42**	8.64***	3.33***	-0.14	-0.047
	(5.9)	(4.2)	(2.4)	(2.5)	(4.0)	(4.3)	(0.2)	(0.3)
*INDREG*ave*	-0.007	0.004***	-0.001	0.002**				
	(0.7)	(3.2)	(0.4)	(2.2)				
*INDREG*dum*					0.89	-0.15	2.23**	0.31**
					(0.8)	(0.8)	(2.2)	(2.2)
AGGLOM	157.88	-128.06*			275.88	-19.08		
	(1.0)	(1.9)			(1.0)	(0.2)		
*AGGLOM*INDREG*	-12.99***	-4.41***			-13.03***	-4.99***		
	(4.1)	(3.5)			(3.6)	(3.7)		
TRANS			-1.93	-1.33***			-2.17	-1.00***
			(1.2)	(3.6)			(1.4)	(3.0)
*TRANS*INDREG*			-9.23***	-3.69***			-10.83***	-4.20***
			(4.3)	(6.1)			(5.4)	(6.6)
Observations	579	579	579	579	579	579	579	579
R-squared	0.13	0.17	0.19	0.23	0.12	0.18	0.21	0.26

Robust t statistics in parentheses
* significant at 10%; ** significant at 5%; *** significant at 1%

Industry and year effects included. *INDREG*ave* is *INDREG* multiplied by average *INDREG* within each industry over time. *INDREG*dum* is *INDREG* interacted with a dummy =1 for the 5 industries with the highest levels of *INDREG*.