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Abstract

This paper examines the impact of trade policy on total emissions of greenhouse gases in an emission-augmented Melitz model that accounts for heterogeneous firms and international asymmetries. Trade improves efficiency through selection and share-shifting effects on firms, and thus if more productive firms match with cleaner technologies, symmetric trade openness can improve overall environmental quality. Yet emission technologies, economic characteristics and trade barriers are highly asymmetric across countries. This can lead to some unexpected implications of national trade policies on total carbon emissions. We find that, even in an asymmetric setting, trade openness can help reducing global emissions. However different effects act together depending on the size, productivity and emission profile of the trading partners. We then resort to a simple parameterization of the model to show the effect of different forces. Our results suggest that trade liberalization can unambiguously lower emissions if coupled with transfers of green technology.

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1. INTRODUCTION

Shifting to a green economy and curbing global emissions is a gargantuan task. Most of the carbon mitigation efforts must come from within national borders and involve difficult domestic policy choices. There is, however, an enduring interest in the role that international trade policy can play in helping or hindering the transition to a low-carbon future. This link between trade policies and emissions arises frequently in the debate, since firms subject to domestic pro-green taxes and regulation routinely decry the loss of international competitiveness that such policies may imply. This paper contributes to this discussion about the trade-environment link by modelling explicitly the problem at the firm dimension.

An impressive theoretical and empirical literature has addressed the trade-environment nexus. Two mechanism of action are often mentioned. First, there is the so-called Environmental Kuznets Curve (Grossman and Krueger, 1993), which postulates that equilibrium pollution first rises and then falls as citizens get richer. Since trade generally boosts v š] } v • [À Œ P] v } u-green link depends upon the channel of raising national income levels. Second, is the Pollution Haven Hypothesis (Copeland and Taylor, 1995) whereby trade by allowing nations to specialise production in their low-cost sectors shifts pollution-intensive activities to nations with lax (and thus low cost) carbon regulation schemes. A known hypothesis is that policy setting with the Pollution Haven Hypothesis in u] v o • š } Z Œ š } š Z } š š } u [} v. v À] Œ } v u v š • š Œ] v

These channels, however, were identified in simple, standard trade models that focused on Z } u } P v } µ • ( ] Œ u • (} Œ } v À v] v U • µ Z • š Z Z } o [š Œ š Z } K Z o] v u } o • • v š Z Z v Á [š Œ -Krugman and Helpman v Œ

2. BACKGROUND

The old trade and environment literature on Environmental Kuznet Curves and Pollution Havens are extensions of well know trade results and growth theories. The most recent literature, driven by new competitiveness concerns related to climate change regulation, is now mor

different pollution technologies, different size, different firms (productivities) to see the effects on total pollution emissions.

3. MODEL

3.1. Production

We begin with a baseline model akin to Melitz (2003), Helpman, Melitz and Yeaple (2003), Baldwin (2005) and Baldwin and Forslid (2006). The key addition is represented by emissions technologies, which match to firms with heterogeneous productivities. Initially we work with nations that are symmetric in all but their average emission technology. As we shall see, even in this simple scenario the effects of trade policies are non-trivial with carbon leakage in some situations. We subsequently consider additional asymmetries such as country sizes and production technology.

The baseline model considers two nations (Home and Foreign) with identical tastes, size and production technology, interacting trough international trade. We think of Home as the developing country with initially dirtier industries. Foreign is a developed country with cleaner technologies and possibly environmental concerns on its agenda. Each country has two sectors of production: a Walrasian sector - characterized by perfect competition, constant returns to scale, and homogeneous goods - and a manufacturing sector - characterized by differentiated products, monopolistic competition à la Dixit-Stiglitz (1977) and increasing returns to scale. As usual in these models, we embrace the simplifying assumption of costless trade in the Walrasian sector and costly trade in the manufacturing sector. As is well known, this equalises Home and Foreign wages and thus cuts out wage-linked channels of endogeneity. This is useful since we believe the wage effects of green-linked trade policies are second order compared to the competitiveness and environmental impacts.

Preferences of all consumers are Cobb-Douglas with the fraction of expenditure on u v µ (š µ Œ P } } • Tastes over the Dixit-Stiglitz varieties are CES as usual. Thus

$$U = \ln R + \ln \left[\int_{i \in \Omega} (p_T)^{1-\rho} \, di \right]^{\frac{1}{1-\rho}} \qquad (1)$$

where R is expenditure, P the price index, p_i is the price of a variety i (we choose units of the Varian good so its price equals unity, $p_T = 1$). Sigma is the elasticity of substitution among varieties, with $0 < \rho < 1$, and Ω the set of all varieties consumed.

3.2. Production

Manufacturing is characterized by a number of fixed costs. All firms pay the standard Dixit-Stiglitz fixed cost of introducing a new variety, F_E (cost of developing a blueprint). Firms that decide to sell domestically must pay a fixed cost of F_D to enter the home market. Firms that also export pay an additional beachhead cost $F_X > F_D$. Additionally, production entails a variable (marginal) cost, a. And finally, exporting goods faces an additional variable cost related to trade frictions, so it costs $\tau > 1$ to sell a unit abroad; $\tau - 1$ encompasses trade barriers such as ad valorem tariffs, or green-linked taxes. Firms are heterogeneous in their variable costs of production, or unit labour input requirements, a. Namely, firm-i's output x_i is:

$$x_i = \frac{l_i}{a_i} \tag{2}$$

where l_i is labour employment. Taking Home labour as numéraire, the wage is unity, so a_i is the marginal cost. Standard calculations show that:

$$p_i^* = \frac{a_i}{1 - 1/\rho}, \quad p_i^* = \frac{\tau a_i}{1 - 1/\rho} \quad \pi_i = \frac{R}{\rho} \tag{3}$$

where c, p and π are the consumption, price and operating profit of a typical variety, and τ is the iceberg trade cost. Equation (3) shows that the optimal price is a constant mark-up over marginal cost, and that all varieties have the same sales and operating profits, regardless of their prices; R is total consumer expenditure on variety i, counting both domestic and export sales (if any). Observe that the lowest firms (with lowest a) have lower prices, higher output and higher profits. In this paper we take R as a parameter to reduce the amount of uninformative clutter. It would be simpler but uninformative to embed our demand structure in a quasi-linear setting where R became a taste parameter.

3.3. Emissions

A number of empirical studies that find that, generally, more productive firms are also cleaner (Batrakova and Davies 2012, Cole et al 2005, Cole and Elliot 2003, Cui et al. 2012,

associated with production for domestic sales. Using equation (3), the emission associated with domestic sales of typical firm i are:

$$e_i = a_i^{\varepsilon} \frac{p_i^{\sigma} R}{P^{1-\sigma}} = (a_i^{\varepsilon})\frac{R}{(1-1/\sigma)^{\sigma} P^{1-\sigma}} \quad (5)$$

When $\varepsilon < \sigma$, emission technology does not compensate the elasticity of substitution that causes more output to be produced: per firm emissions associated with consumption of a variety are increasing in a_i and efficient firms sell less units of output. If the inequality is reversed, emissions are higher for the most efficient firms since, even if they pollute less per unit, the sell many more units than least efficient firms.[8] This is particularly important when analysing selection effects and carbon leakage arising from green-linked trade policies. In what follows, we model the developing nation (Home) as having a lower ε than ε^*, so that on average Foreign firms are cleaner than Home firms.

3.4. The Pareto distribution

As is standard in the literature, we assume that a is distributed randomly from a Pareto distribution[9] with cumulative density function $G[a] = a/a_0^{k}$ and probability density function $g[a] = k a^{k-1}/a_0^{k}$ where $k > \sigma - 1$ is a shape parameter. This restriction ensures that the variance of firm sales is finite, which in turn ensures that the present value of any firm is finite. It is useful to segment the population of firms into three types. N-type firms enter by paying F_I, only to discover that they are too inefficient (i.e. their a is too high) to make production worthwhile, so they produce nothing. D-type firms pay F_I and find that they have a productivity a low enough to make sinking F_D worthwhile, but not F_X.

domestically and abroad; we call these types. Two endogenous thresholds $a_{X,}$ and $a_{D,}$ define the types as

$$a_D \equiv \left(\frac{f_I}{f_D}\right)\frac{1}{(J-1)(1-:)}\right)^{\frac{1}{\alpha}} \qquad a_X \equiv \left(\frac{f_I}{f_X}\right)\frac{:}{(J-1)(1-:)}\right)^{\frac{1}{\alpha}} \tag{8}$$

While countries are identical in terms of production, exports and consumption, they have different emissions profiles since they have different emission technology. Specifically, emissions at Home are:

$$E \equiv n\left[f_D + \left(a_D^{1-\varepsilon} + a_X^{1-\varepsilon}\right)\right] \equiv \left[\frac{k(V-1)}{k-V+\varepsilon V}\right] \tag{9}$$

Full derivation of this result is given in the Appendix. Foreign emissions take the same form,

productivity to sell in the domestic market, a_D, falls due to the extra competition from new foreign firms. This means that the least efficient Home firms in the market – those that have profits barely sufficient to pay the fixed cost of producing – are forced out, and their market shares are reallocated to top firms, that now also serve foreign markets. These two interesting mechanisms, the selection effect on firms at the bottom of the distribution and the expansion of the top of the distribution in the export market, cannot be observed when firms are homogeneous. They are instead clear in this model, because of the change in the efficiency thresholds caused by trade. Fig. 2 illustrates the effect of different trade openness levels on a_D and a_X. The change in threshold values is where most of the action takes place also in terms of determining emissions per country, therefore it is very important to identify their change after trade liberalization. The effect of a tariff or other measures to increase variable trade costs would simply operate in the opposite direction.

Fig.2 – Effect of tariffs on productivity thresholds

Which threshold changes more, in absolute terms? As more productive firms exporting or more unproductive ones exiting? For the fall in the domestic threshold to be greater than the rise in the one of exporters, we need

$$\tau^{\frac{k}{1-k}} \left(\frac{f_x}{f_d}\right)^{\frac{1}{1-k}} \quad (10)$$

[12] Or more precisely $\left(\frac{f_x}{f_d}\right)^{\frac{1}{k(1-k)}}$

$$\frac{1}{(1-\varepsilon)}\left(\frac{\varepsilon}{(\varepsilon-1)(1-\varepsilon)}\right)^{\frac{1}{k}}\left(\frac{\varepsilon-1}{\varepsilon}\right)^{\frac{1}{k}}\left(\frac{\varepsilon-1}{\varepsilon}\right)^{\frac{1}{k}}\left(\frac{1}{k}-1\right) \tag{12}$$

The effect on the number of firms producing is unambiguous - as it can be seen in Fig. 3 below or by inspection of equation (A3) in the Appendix. This is inevitable since the average firm pays a higher fixed cost (more firms pay both F_D and F_X), and hence the average firm needs higher sales to cover the fixed cost. As the aggregate size of the world market does not change, higher average sales require fewer

Fig. 4 t Home (left panel) and Foreign emission (right) as trade openness rises. Home emits more than Foreignt µ š } o } Á Œ Blue solid Z] v Œ ‰ Œ • v š • t E • U š Z Œ } v t D • X

/ š o Œ o Ç (} o o } Á • š Z š P o } o u] • •] } v • U] X X š Z • µ u } (š Z

unambiguously in the first case, when the emissions technology is sufficiently clean, but not

This can give rise to some particular situations where the only option to reduce emissions would be to adopt some protective trade measures. Alternatively, if the countries do not want to impose trade barriers, for instance due to WTO regulations, the most advanced one could transfer some clean technology to the less clean one, to ensure that its emission profile goes to the situation depicted in the blue solid line.

This simple symmetric setting allowed us to build intuition for more complex cases, as it highlights a key prediction of this emission-augmented Melitz model. Namely, in so far as trade liberalization improves efficiency (via selection and expansion of the most efficient firms) and efficiency is negatively linked to emissions, we can get an improvement in total emissions so long as the negative emissions-efficiency link is sufficiently strong. As shown above, t

4.1. Trade policy and asymmetric size

Changing the variable cost of trade, τ, or fixed costs, F_X, produces economic effects as those studied in Baldwin and Forslid (2010). For variable costs liberalization (lower τ) with nations of different size, we get a Home Market Effect (HME): $\uparrow\tau \Rightarrow \uparrow\frac{n}{n^*}$ rises more than proportionally in the big

Fig. 6 t d } š o u] • •] } v • v •] Ì X Z • Z o] v W } š Z } µ v š Œ] t • Á] š Z ^ D ; blue solid line both countries have t E; green dotted line: Home has t D while Foreign has t* > • *.

This scenario gives a useful indication about what would happen in case of a demographic boom or a large increase in purchasing power. By boosting the size of a developing country that uses polluting technologies, the exogenous growth factors tend to worsen the environment. More to the point, greater relative size asymmetries make the Home Market Effect stronger, so even at a given level of trade liberalization the demographic increase is likely to worsen emission

The story depicted in Fig. 7 is similar for the Foreign country, just with better parameters and therefore lower emission levels to begin with. For global emissions, the sum of Home

Fig.8 t ,}u u]••]}v• (oo Á]šZ }‰ vv ••U]v ‰ v všoÇ }(šZ Œ •X

For the most advanced country, the effect on emissions is ambiguous and depends also upon t (Fig. 9). In general, the most productive and cleanest country risks to lose more from opening up to trade with a dirty, inefficient partner in terms of own emissions.

BIBLIOGRAPHY

Baldwin, R. E., & Forslid, R. (2010). Trade Liberalization with Heterogeneous Firms. Review of Development Economics, 14(2), 161-176.

Baldwin, R., & Okubo, T. (2009). Tax Reform, Delocation, and Heterogeneous Firms. Scandinavian Journal of Economics, 111(4), 741-764.

Bardhan, P. K. (1966). International Trade Theory in a Vintage Capital Model. Econometrica, 34(4), pp. 756-767.

Barrett, S. (1994). Strategic environmental policy and intrenational trade. Journal of Public Economics, 54(3), 325-338.

Barucci, E., & Gozzi, F. (2001). Technology adoption and accumulation in a vintage-capital model. Journal of Economics, 74(1), 1-38.

Batrakova, S. & Davies, R. (2012) Is there an environmental benefit to being an exporter? Evidence from firm-level data. Review of World Economics, Springer-Verlag, 148, 449-474.

Breinlich, H., & A. Cuñat (2010) Trade Liberalization and Heterogeneous Firm Models: An Evaluation Using the Canada-US Free Trade Agreement. CEP Discussion Papers dp0975, Centre for Economic Performance, LSE.

Cole, Matthew A., Robert J. R. Elliott, and Kenichi Shimamoto (2005) `Industrial characteristics, environmental regulations and air pollution: an analysis of the UK manufacturing sector.' Journal of Environmental Economics and Management, 50(1), 121-143.

Cole, Matthew A., & Robert J. R. Elliott (2008) `Industrial activity and the environment in China: An industry-level analysis.' China Economic Review, 19(3), 393-408.

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Dean, J. M., Lovely, M. E., & Wang, H. (2009). Are foreign investors attracted to weak

Kreickemeier, U., & Richter, P. M. (2012). Trade and the Environment: The Role of Firm Heterogeneity. CESifo Working Paper Series, CESifo Group Munich.

Krugman, P. (1991). Increasing Returns and Economic Geography. Journal of Political Economy, 99(3), 483-499.

Markusen, J. R. (1995). The Boundaries of Multinational Enterprises and the Theory of International Trade. The Journal of Economic Perspectives, 9(2), pp. 169-189.

Markusen, J. R., Morey, E. R., & Olewiler, N. D. (1993). Environmental Policy when Market Structure and Plant Locations Are Endogenous. Journal of Environmental Economics and Management, 24(1), 69-86.

Mazzanti, Massimiliano, & Roberto Zoboli (2009) `Environmental efficiency and labour productivity: Trade-off or joint dynamics? A theoretical investigation and empirical evidence from Italy using NAMEA.' Ecological Economics 68(4), 1182-1194.

Melitz, M. J. (2003). The Impact of Trade on Intra-industry Reallocations and Aggregate Industry Productivity. Econometrica, 71(6), 1695-1725.

Shimer, R., and L. Smith (2000) Assortative Matching and Search. Econometrica, 68(2), 343-370.

Ulph, D. (1997). New Directions in the Economic Theory of the Environment. In C. Carraro, & D. Siniscalco (Eds.). Cambridge University Press.

Wheeler, D., Hettige, H., Martin, P., & Singh, M. (1995). The Industrial Pollution Projection System. World Bank, http://elibrary.worldbank.org/content/workingpaper/10.1596/1813-9450-1431.

Zeng, D.-Z., & Zhao, L. (2009). Pollution havens and industrial agglomeration. Journal of Environmental Economics and Management, 58(2), 141-153.

To close the model, we use the free entry condition (7) and find the two thresholds. For more detail on the calculation of thresholds, we refer the reader to pp. 25 of Baldwin and Forslid (2010) working paper (Guide to calculation).

Solving for total emissions, we sum up emissions in (4) for all firms in a nation

$$E \quad n \int_0^{a_D} a^{E} c(a) \quad dG(a) \mid a_D \quad @n \int_0^{a_X} a^{E} c^*(a) \quad dG(a) \mid a_D \qquad \text{(A4)}$$

where $c(a)$ and $c^*(a)$ are given by (3) Using the formulas above, we can express this as:

And using the Pareto distribution this solves to:

Using the cutoff conditions (6), we can rearrange this as

$$n \frac{k(V \; 1)}{k \quad V \quad E V} \left[f_D a_D^{E1} \quad f_X a_X^{E1} \left(\frac{a_X}{a_D} \right)^{k} \right]$$

And finally, collecting f_D

Section 4 - Derivations

4.1. Solving simultaneously for n and n*: again, see Guide to calculation in Baldwin and Forslid (2010), pp. 26ff. It is sufficient to solve simultaneously the two domestic cutoffs (15) (16) for n and n*.

4.2. ^ } o À] v P š Z ‹ µ] o] Œ] µ u Á Z v š Z ( ] Œ u • [u] • š Œ] µ š } v •] ((

2008).The results are quite complex, therefore it is not possible to see analytically the effect of a change in Omega on emissions. We resort to graphical illustrations to exemplify more clearly the effects of trade policies. Intuitively, if Foreign imposes trade barriers, these affect the Home thresholds directly through the cost of accessing the foreign market; however, even if the openness of Home remains constant, also the thresholds of the Foreign country are affected through their price index.

Calibration parameters

World Emissi ons - Figures

Fig.A1 t

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Fig. A2 t Different productio