Can the terms of trade externality outweigh free-riding? The role of vertical linkages☆

Christian Bogmans *

Department of Economics, University of Birmingham, United Kingdom

ABSTRACT

This paper analyzes the impact of vertical linkages on the international effects of environmental policy. With vertical linkages, stricter environmental policy at home indirectly reduces pollution in the rest of the world. This spillback effect can reinforce the free-rider problem that arises under strategic interaction. When pollution is transboundary a race to the bottom ensues, despite the fact that vertical linkages make it easier for national regulators to export the costs of environmental policy via the terms of trade. We also find that while trade liberalization can be good for the environment, vertical linkages tend to increase global pollution.

© 2014 Elsevier B.V. All rights reserved.

1. Introduction

Going back at least to Leontief (1970), scholars have recognized the importance of accounting for inter-industry relationships when tracking the environmental repercussions of economic activities. For at least two reasons, this insight has become increasingly relevant at the global level. For one, international fragmentation of production processes has created a myriad of cross-border inter-industry relationships, with intermediate goods trade growing more rapidly over the last few decades than total trade (WTO, 2008). According to Yeats (2001) intermediate input trade already accounted for roughly thirty percent of world trade in manufacturing goods in 1995.[1] Furthermore, in recent years policymakers have shifted their attention to global environmental

problems, such as the control of anthropogenic greenhouse gas emissions. Despite a surge in empirical work in the trade and environment literature that uses input–output (I–O) methods to account for inter-industry dependencies, see e.g., Levinson (2009), Davis et al. (2011) and Aichele and Felbermayr (2012), it remains unclear how the effects of environmental policy will play out in a world where these dependencies, or vertical linkages, have gained importance.

This paper analyzes the impact of vertical linkages on the international effects of environmental policy. Here we refer to an intermediate good as being interdependent or interconnected through vertical linkages if the production of that particular intermediate good, say a car, is enabled by the input of other intermediate goods, say steel plates, tires or industrial robots, that are potentially sourced from abroad. We argue that vertical linkages shape the incentives facing national regulators concerned with environmental policy in important ways. For one, vertical linkages increase the (opportunity) cost of domestic environmental policy. Additionally, linkages increase the extent to which the costs of environmental policy are exported to the rest of the world via the terms of trade (ToT). On the other side of the same coin, we find that some of the benefits, i.e., emission cutbacks, are exported as well. The latter implies that in the presence of vertical linkages domestic environmental policy reduces emissions abroad.

We determine what happens to global pollution in a world where producers in different countries are becoming increasingly interconnected via vertical linkages and countries set environmental policies non-cooperatively. The outcome of this non-cooperative game is then

compared to the outcome under full cooperation, where countries coordinate their policies so as to maximize global welfare. We find that vertical linkages, whether countries cooperate or not, tend to increase global pollution.

We generalize the production structure of the Armington type model of Acemoglu and Ventura (2002) by adding vertical linkages, trade costs and transboundary pollution from intermediate goods production. Each country produces a unique set of tradable intermediate goods using domestic labor and a produced input, i.e., a CES aggregate of all available intermediates. If the dependence of intermediate goods production on produced inputs increases, vertical linkages are said to become stronger. In this simple general equilibrium model, both trade liberalization and stronger vertical linkages bring about an increase in the degree to which intermediates are produced using imports, a process referred to as vertical specialization (see Hummels et al. (2001) and Yi (2003)).

In the first part of the paper we analyze both the marginal costs and benefits of unilateral environmental policy. Naturally, the results obtained here are required for the normative analysis in the second part of the paper, but they also prove to be interesting in their own right. Of primary interest here are a country's ability to export the costs of environmental policy via changes in the ToT and the sign of pollution leakage, defined as the change in pollution abroad in response to an increase in the stringency of environmental policy at home.

Three findings emerge. First, we show that once countries are mutually dependent on the import of intermediates through vertical linkages, a novel channel for environmental policy opens up. By reducing the net supply of intermediate goods to world markets, a stricter domestic environmental policy spills over to the rest of the world where it indirectly reduces output in the import-dependent intermediate goods sector. As in the traditional work on input–output analysis (see Leontief (1970)), the negative global supply effect sets in motion another round of reductions in all countries so that the initial effect is magnified. Second, because of this input–output magnification effect, vertical linkages also increase the opportunity cost of environmental policy. Third, we find that vertical linkages not only raise trade intensity, but also lower the net import elasticity of demand, implying larger ToT effects.

Even though the production and consumption of intermediate goods tend to shift to producers in unregulated countries, this is not sufficient to offset the global supply effect. The first main contribution of the paper is therefore to explain the occurrence of negative leakage, with pollution in other countries not increasing, but decreasing under unilateral policy. Negative leakage is an interesting and surprising outcome, as most studies have focussed exclusively on the opposite case of positive leakage, see e.g., Babiker (2005).

In the second part of the paper we then apply the comparative static results to study optimal non-cooperative and cooperative environmental policies. Whether strategic interaction between national policymakers leads to levels of pollution that are inefficiently high, depends on the geographic scope of the relevant pollutant and hence on the relative strength of the terms of trade motive and the free riding motive, two externalities that lie at the heart of our normative analysis. As national interests are assumed to be of paramount importance to domestic regulators, they ignore the positive impact of domestic environmental policy on the rest of the world. This incentive, here referred to as free-riding, is reinforced by vertical linkages as regulators fail to take into account that a reduction in pollution abroad also spills back to other countries.

We show that if pollution spillovers are strong, as in the case of greenhouse gas emissions, the incentive to free-ride always overwhelms the ToT motive, countries install relatively weak environmental standards and a race to the bottom ensues. In situations where national policymakers are dealing with pollutants that are local in scope, the dominant terms-of-trade externality invokes stricter standards and a race to the top is obtained instead.

While the ToT externality may thus never outweigh free-riding in the case of transboundary pollution, we do find, however, that linkages can soften the race to the bottom result. This constitutes the paper's *second contribution*. Whether a certain reduction in emissions is realized at home or abroad, becomes irrelevant when the geographic scope of pollutants is global. In that case, the exporting benefits effect does not influence decision making. Stated otherwise, when pollution is transboundary, vertical linkages do not affect the degree of free-riding. With only the enhanced ToT motive left, the non-cooperative policy then partially converges to the cooperative policy when linkages grow stronger.

Finally, as a *third and main contribution* we show that when countries become increasingly interdependent via vertical linkages, the net marginal benefits of pollution grow larger and global pollution tends to increase. This result, relevant for both cooperative and non-cooperative policy, arises from the opportunity cost effect. When production is increasingly reliant on produced inputs, many of which are sourced from all over the world, labor becomes increasingly productive. It is therefore more costly to divert resources away from production towards pollution abatement.

Our main contribution has implications for the relationship between vertical specialization and the environment. Although trade liberalization and input–output linkages both raise the degree of vertical specialization, only trade liberalization can potentially lower pollution. Whether vertical specialization is thus good or bad for the environment depends crucially on whether its expansion is driven by stronger vertical linkages or by trade liberalization.

This paper relates to a number of strands in the literature. In the literature on trade and the environment the environmental consequences of trade in intermediate goods are relatively unexplored. Some important exceptions are Benarroch and Weder (2006), McAusland (2004) and Hamilton and Requate (2004). None of these studies, however, study the relationship between vertical linkages and environmental policy in a multi-country general equilibrium model.

Our work is also related to a concern that globalization will intensify regulatory competition in national environmental policies, thereby provoking a race to the bottom with negative consequences for global environmental quality (see Ederington (2010)). As we have argued, this does not represent a necessary outcome, because ToT effects could induce a race to the top instead. Using trade flow data for the US and Canada, McAusland and Millimet (2013) find robust evidence that international trade, but not intranational trade, exerts a beneficial effect on environmental quality, a result that is consistent with the ToT channel.[2] Markusen (2013) is another study emphasizing that the costs of environmental policy can be exported via the ToT, but he does not consider the role of vertical linkages, nor is he concerned with the feasibility of negative leakage.

Last but not least, a small number of papers has explored the possibility of negative leakage in analytically tractable trade models. Using a two-sector model with three factors of production, Karp (2013) shows that unilateral regulation lowers national income, reduces demand for both clean and dirty goods and shifts domestic production factors into home's dirty goods sector. This factor mobility effect obviates the need for dirty goods supply abroad, thereby promoting negative leakage. Baylis et al. (2014) show that negative leakage can result from a so-called abatement resource effect; by increasing its demand for the internationally mobile factor of production, the regulated sector in the policy active country crowds out production in the unregulated sector abroad.

Similar to Baylis et al. (2014) and Karp (2013), we use a tractable trade model to highlight a channel for negative leakage. Whereas in these papers the (international) mobility of production factors is key,

---

[2] Broda et al. (2008) provide strong empirical evidence for terms of trade considerations playing an active role in the formation of trade policy. Consistent with the theory on optimal tariffs, they find that non-WTO members systematically set higher tariffs on imports that are supplied inelastically.