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Trade Liberalization and the Porter Effect: Theory and (preliminary) Evidence from Mexico

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ABSTRACT

Does trade liberalization make the environment dirtier or cleaner? Theory suggests the possibility of both. Copeland and Taylor's (2003) composition effect changes the mix of goods produced either according to comparative advantage, or due to foreign factor inflows, particularly capital. The composition effect may or may not cause degradation of the environment in the country that has a comparative advantage in the production of pollution intensive goods. Ederington et al. 2004, that trade liberalization does not exacerbate the building up of pollution havens in less developed partner countries, a prime example being Mexico. Kahn and Yuchino (2004) find that NAFTA did not produce pollutions havens in Mexico. Why that is so is the working hypothesis that motivates our study.

The "Porter effect" (Porter and van der Linde1991; Porter1995) is the idea that environmental regulation actually spurs innovation that is both, environment-friendly as well as productivity-improving. This hypothesis focuses on innovation "offsets", or the ability of properly designed environmental standards to trigger innovation that may offset partially or fully the cost of complying with these standards. The Porter hypothesis runs diametrically counter to the pollution haven hypotheses. Much evidence supporting this hypothesis is in the nature of case studies. This paper aims to fill this gap in the literature.

The paper presents a theoretical model depicting the Porter effect in general equilibrium. It proposes hypotheses that may be tested using data from Mexico. We hope that Mexico's EPA – the two bodies PROFEPA and SEMARNAT -- which are entructed with the effort to collect pollution data at the firm level will add new dimensions to their data collection efforts so that this important relationship between trade liberalization and (possibly good) environmental outcomes may be tested.

1. INTRODUCTION

Does trade liberalization in the form of regional trade agreements make the environment dirtier or cleaner? Theory suggests the possibility of both. Copeland and Taylor (2003) describe the composition effects from trade liberalization which changes the mix of goods produced either according to comparative advantage, or due to foreign factor inflows, particularly capital. The composition effect may or may not cause degradation of the environment in the country that has a comparative advantage in the production of pollution intensive goods. Kahn and Yuchino (2004) show that regional trade blocks actually improve the environment. In their model, while exports expand with bloc formation the volume of exports vary less with pollution intensity as compared to the case of bilateral trade before the block was formed. Regibeau and Gallegos (2004) argue contrarily. In their model trade policy is used by the government as a threat to motivate domestic firms to adopt cleaner technologies. The government has an incentive to protect the clean industry, and exercises this incentive. According to his theory, trade liberalization, by taking away the government's ability to use trade policy as a threat to enforce stricter environmental standards, hurts the environment of the liberalization country.

Evidence is accumulating on this issue. Ederington et al. (2004) study trade liberalization and its impact on the environment in the U.S. using panel data in the U.S. between 1972 and 1994. They seek to investigate the composition hypothesis more deeply. They find that even though the manufacturing sector in the U.S. has shifted toward cleaner industries during the twenty-year period during which tariffs on imports fell by over fifty percent, there is no evidence that domestic production of pollution intensive goods in the US was replaced by imports by from overseas. What is surprising about this finding is that it appears that trade liberalization does not exacerbate the building up of pollution havens in less developed partner countries, a prime example being Mexico. Kahn and Yuchino (2004) find evidence that for NAFTA the pollution haven is strongly mitigated. They speculate that this is because NAFTA made greater commitments (than other RTAs) to harmonizing environmental policies within the block. In sum, NAFTA did not produce pollution havens in Mexico. Why that is so is the working hypothesis that motivates our study.

The "Porter effect", named for the idea of Michael Porter that environmental regulation actually spurs innovation that is both, environment-friendly as well as productivity-improving, is an attractive alternate hypothesis to the pollution haven hypothesis, which holds that developed country firms will flock to developing countries to take advantage not just of the cheap skilled labor available there but also the lax regulation which lowers the cost of producing dirty goods. The Porter hypothesis (Porter and van der Linde1991; Porter1995) focuses on innovation "offsets", or the ability of properly designed environmental standards to trigger innovation that may offset partially or fully the cost of complying with these standards. Porter and van der Linde (1995) advance the notion that innovation offsets can be a source of absolute advantage over competing firms not subject to similar to similar regulations. The Porter hypothesis is entirely based on the private cost-benefit analysis performed by firms in the presence of regulation.

The reason that pollution regulation can spur innovation is because the process of innovation and productivity improvements is an uncertain and unforeseeable. Further, the experience with environment friendly technology is in its nascent forms in most countries and sectors. A focus on the environment can therefore lead to technological progress in ways unimagined before the last twenty years. The Porter hypothesis runs diametrically counter to the pollution haven hypotheses. A large literature has grown around this issue (see Lucas et al 1992; Dean 2002; and papers contained in Low 1992). More recently, Eskelund and Harrison (2002) find that though US outbound fdi (foreign direct investment) is skewed towards industries with high cost of pollution abatement, these foreign plants are significantly more energy efficient than their host country firms. In contrast, there is little direct evidence about the Porter hypothesis in a trade context. Much evidence supporting this hypothesis is in the nature of case studies. This paper aims to fill this gap in the literature.

Further, evidence about trade and environment is generally "distant", since these studies are at the level of countries and industries. Because they are at such a highly aggregate level, these studies are unable to capture the mechanism by which trade liberalization leads to cleaner environmental. In that sense they are unable to distinguish, say, political economy at work or the ability of the income effect to dominate the composition and scale effects. We encourage a study using a more direct chain of events that may lead trade liberalization to result in a cleaner environment. Data at the level of the firm, specifically post-NAFTA data from Mexico, would be ideal to test our hypotheses, which concern the following questions:

- Has trade liberalization in NAFTA countries spurred investments that are environment-friendly?
- Has trade liberalization in NAFTA countries altered environmental polices in investment receiving nations like Mexico. ?
- Why do firms undertake such investments?
- Do investments by multinational and Mexican firms inside Mexico into cleaner technologies and environmental clean-ups have favorable environmental consequences?
- Has NAFTA encouraged stricter environmental regulation in Mexico and why?

2. THEORY

Our theory emphasizes the Porter effect within a general equilibrium model of production and trade. The general equilibrium model with one clean good and one polluting good has been developed in Copeland and Taylor (2003, Ch. 2), and we embed the Porter effect within this model. The Porter effect is a theory of how tighter environmental regulation can actually be a source of competitiveness for firms with cleaner technology. First, we describe the Copeland-Taylor model graphically.

The economy produces a clean good Y and a pollution-producing good X. F is potential output that is the maximum output of X (when there is zero abatement). Otherwise, $X=(1-\theta)F$, where θ is the proportion of F used for abatement. F is produced using capital and labor with CRS. Z is output of pollution, and is given by $(1-\theta)^{1/\alpha}$ F, where $0<\alpha<1$. Abatement costs τ per unit of emission. Net output X is produced in two stages: in the first stage the cost minimizing technique of producing a unit of F is determined using labor and capital; in the second stage Z is optimally abated. Effectively, F and Z are inputs into the CRS production of X, which is given by $x = z^{\alpha}.F^{(1-\alpha)}$. Thus, α is the share of abatement costs (τz) in the value of net output (px).

Figure 1 shows the cost minimizing unit isoquant (I_1) for X using inputs F and Z. It is defined to the right of the 45 degree line, along which there is complete abatement (by choice of units, one unit of output generates one unit of pollution: F=Z). Denoting the minimum cost (as a function of wage and rents) of producing a unit of F as c^F, the slope of the isocost line is $-c^F/\tau$.

Porter and van der Linde's (1995) "product offsets" and "process offsets" are sources for new environment-friendly technologies. Product offsets occur when environmental regulation produces less pollution and also better performing and higher quality products lower product cost (e.g. through higher resale, lower product disposal). Process offsets occur when environmental regulation reduces pollution and also higher resource productivity (e.g. through high process yield, less down time, materials savings, lower energy consumption, conversion of waste into usable forms). These offsets result in competitive advantage due to early mover advantage. For example, if a US firm moves into the Mexican market with cleaner technology to produce say, a chemical good, in response to the Mexican government's newly imposed tougher environmental regulation (which is tightly enforced), it gives the US firm early mover advantage, since it is a generation ahead of its competitors in the new regulatory regime. This is not a hypothetical case, but one that is emerging in Mexico as NAFTA issue-linkages provide the Mexican government with the appropriate incentives to begin to strictly monitor environmental standards suggested in the NAFTA agreement. As we will show in the empirical work, the Mexican EPA (PROFEPA) performs precisely this function (see e.g. Braithwaite and Drahos 2000).

Figure 2 shows unit isoquants with more environment-friendly technology. The technology I_2 sacrifices productivity gains on F for greater productivity on the abatement of Z. The technology I_3 is more efficient in both, producing F as well as abating Z. Liberalization policies that encourage FDI (rather than direct innovation) can drive similar results. FDI brings in cleaner technology because, in the presence of a permanent emission charge, source-country firms see a competitive advantage in producing using I_2-technology in an industry in which the majority of firms are using the less efficient I_1-technology.1

Figure 3 shows the impact of an inflow of capital that is biased towards good X. The top part of Figure 3 depicts two production possibility frontiers, PPF_1 and PPF_2. PPF_1 arises from production technology I1 in figure 2 and PPF_2 arises from an inflow of capital that uses the same technology. The outward shift in the PPF is biased towards the dirty good X. P^0 is the world price of X (P^y =1, y the clean good is the numaraire good). The emission intensity of x with this technology is e_1 so that the output of pollution $Z = e_1.x$. This is depicted in the bottom part of figure 3. The figure isolates the pure composition effect of the inflow of capital and from the scale affect of the inflow of capital. Keeping the world price unchanged at P^0 and scaling down production from C to the isocost P^0 yields the point B. The movement from A to B is the pure composition effect while the movement from B to C is the pure scale effect as output expands

1 The isoquant I_3, shows innovation increasing productivity even in the first stage so that less F and less Z can produce a unit of x compared to I2. However, all the figures are based on the I_2 technology, where the offsets occur primarily in the second stage.

along the ray OC. The bottom part of the figure shows that composition effect of producing more X than Y is an increase in pollution by $Z_A^1 Z_B^1$ while the pure scale effect is $Z_B^1 Z_C^1$. q indicates the producer price p(1-α). The line P^0 measures initial output at base period world price, which indicates the initial scale of the economy at point A.

Figure 4 compares the composition and scale effects with the new versus the indigenous technology. The only difference here is the line $Z = e_2x$ which indicates that the cleaner foreign technology has lower emissions intensity e_2.2 As indicated, the composition adds scale effects which are smaller then with the old technology. Therefore, the total pollution is lower. The sum of the scale and composition effects is $Z_A^2 Z_C^2$ compared with the larger $Z_A^1 Z_C^1$ with the older indigenous technology. The difference is entirely due to the technique effect. This is the Porter hypothesis in the context of trade liberalization.

An important consideration for the Porter effect to prevail is the effective design of environmental regulation that encourages innovation. Has Mexico's EPA designed policies that are effective in this sense? That is an important empirical question. One important feature of effective regulation is its permanence. That, by itself, can encourage FDI from developed countries whose firms perceive an advantage to using their greener technology in host countries where competing firms are not equipped to deal with such regulations in the short run. They are forced to adopt a static and costlier way of complying with new regulation, which is to abate within the confines of their current technology. Whether this is true in Mexico is an important empirical question.

3. EMPIRICAL HYPOTHESES

The following hypotheses arise from our theory.

The Porter Effect 1:

H1: Environmental-friendly investments are strongly associated with environmental performance of firms.

(firm performance may be measured by the percentage reduction of environmental contaminants, or by whether the firm earns ISO recognition, or whether the firm earns PROFEPA's recognition for sizable improvement in environmental performance)

The Porter Effect 2:

H2: Firms with long-term interests will make environmental-friendly investments (long term

2 In the figures, we imagine the move from PPF1 to PPF2 to be the same with the capital inflow even though the foreign technology is represented by the environment-friendly isquant I2 (Fig. 2). In reality the PPF shifts will be different, but rather than clutter the figure, we try to make the main point simply: the technique effect lowers both the scale and composition effects with the new technology.

interests may be identified by origin of capital, size of the firm, economic sector of firms, geographical location, etc).

In order to test these hypotheses, data should be broad in the cross-section (many firms) as well as in the time series.

4. DATA

Survey data collected by Mexico's EPA (the two bodies PROFEPA and SEMARNAT) have the potential to be used for empirically testing these hypotheses, but the theory requires more data than are available to date. Specifically, data on actual emissions at the establishment level on a periodic basis is essential. Further, it is important that the data be verifiable. Therefore we have not undertaken empirical testing of the theory.

PROFEPA and SEMARNAT have, however, made a promising start. They periodically survey 3000 establishments, including domestically-owned Mexican firms and transnational firms inside Mexico. The surveys are conducted by auditors under the supervision of the deputy attorney for environmental audits. A portion of the information from the surveys is in raw form on a number CDs. Because of confidentiality, and since data are not completed organized as a data base, the data have not been made available to the public. These surveys have never been used for any analysis. Under an agreement of confidentiality with the deputy attorney for environmental audits we can have access to the information (inside PROFEPA premises). PROFEPA and SEMARNAT are also interested in this line of work since it is one way they can make public their work to the North American audience.

The data potentially has recurring information on the 3000 firms about investments they have made towards cleaner plants, lower emissions, and meeting tougher environmental standards. The Program of Environmental Justice Procuration 2001-2006, was structured in order to monitor geographic zones considered to be critical in the area of natural resources, monitor high risk companies, monitor any breach of the law, apply exemplary sanctions when environmental crimes are committed, and guarantee strict enforcement of the law.

Unfortunately, the data that exist before this 2001 regulatory "structural break" are collected by PROFEPA in a different format that the one used to collected data after 2001. However, PROFEPA is undertaking an important effort to recover information and make it comparable.

How long the top echelons at PROFEPA stays depends on the outcome of elections. Since this is an electoral year in Mexico, it is likely that a new six-year bureaucracy will take over. We will propose to this new group to undertake the construction of a unique data base using information from SEMARNAT and PROFEPA. Then, based on this initial database, we will propose to the authorities how to design mechanisms to encourage correct self-reporting by firms. We can only hope that PROFEPA and SEMARNAT understand how valuable and informative their data are for our purpose, and also how valuable those inferences might be for the NAFTA policy community.

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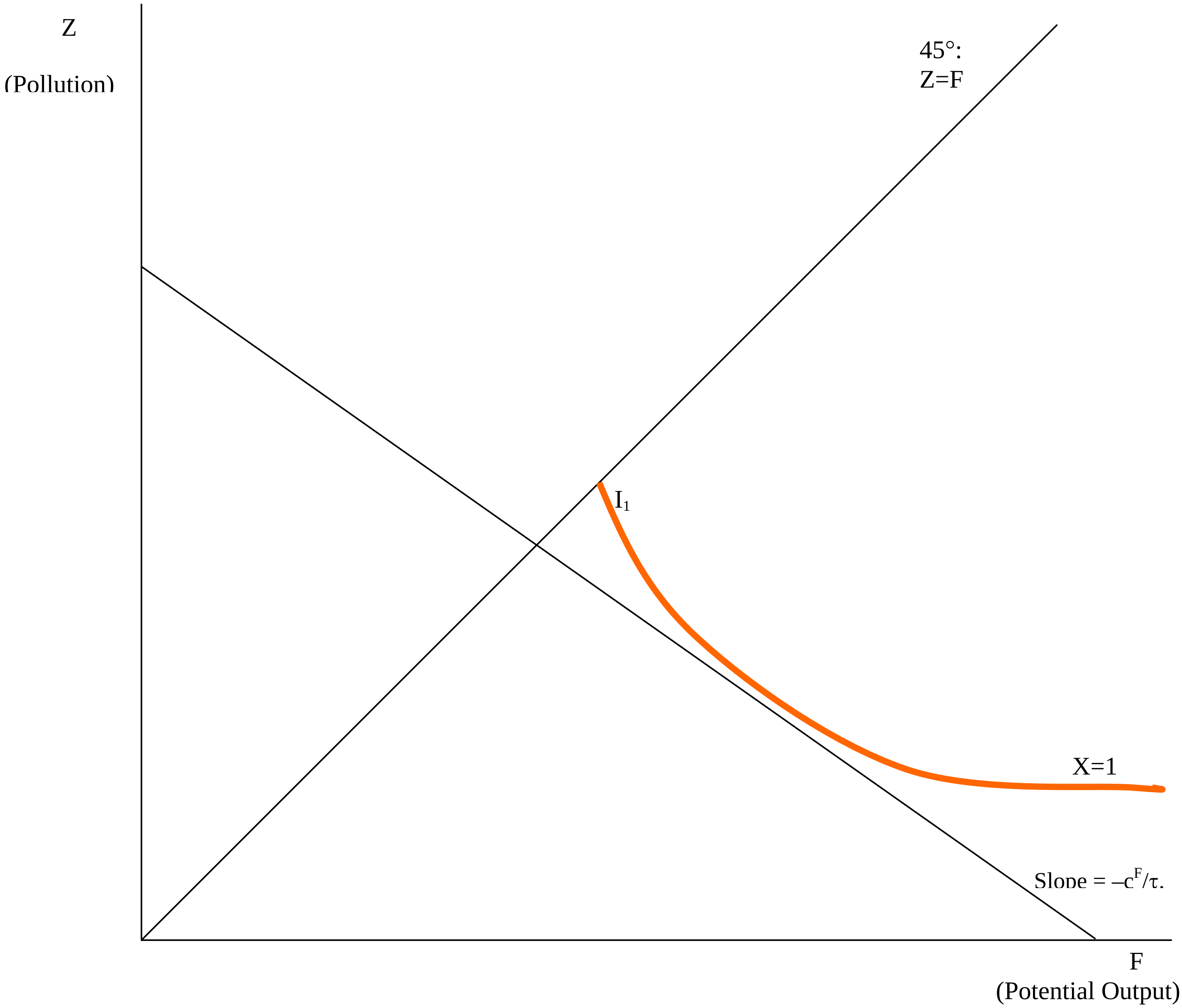

Figure 1: Production with pollution (Copeland and Taylor, 2003)

The economy produces a clean good Y (not in figure) and a pollution-producing good X. F is potential output, that is the maximum output of X (when there is zero abatement). Otherwise, $X=(1-\theta)F$, where θ is the proportion of F used for abatement. F is produced using capital and labor with CRS. Z is output of pollution, and is given by $(1-\theta)^{1/\alpha} F$, where $0<\alpha<1$. Abatement costs τ per unit of emission. Net output X is produced in two stages: in the first stage the cost minimizing technique of producing a unit of F is determined using labor and capital; in the second stage Z is optimally abated. Effectively, F and Z are inputs into the CRS production of X, which is given by $x = z^{\alpha}.F^{(1-\alpha)}$. Thus, α is the share of abatement costs (τz) in the value of net output (px). The figure shows the cost minimizing unit isoquant (I_1) for X using inputs F and Z. It is defined to the right of the 45 degree line, along which there is complete abatement (by choice of units, one unit of output generates one unit of pollution: F=Z). Denoting the minimum cost (as a function of w and r) of producing a unit of F as c^F, the slope of the isocost line is $-c^F/\tau$.

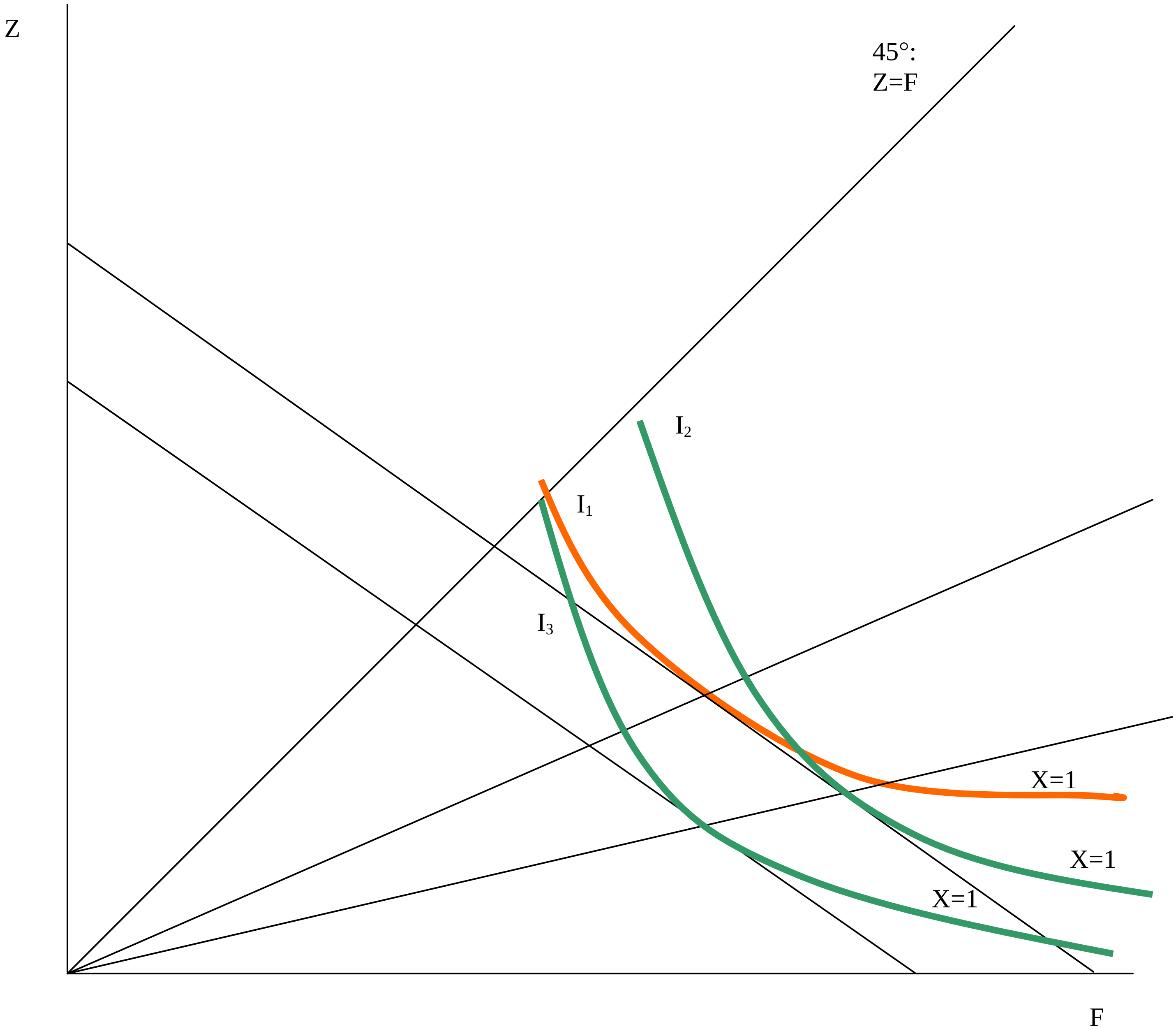

Figure 2: The Porter Hypothesis in general equilibrium.

I_1 is the unit isoquant curve before innovation. I_2 is the unit isoquant curve after innovation, conditional on long-term emission charge of $\$\tau$ per unit of pollution. I_2 and I_3 can result from a number of sources. A second-stage technological change which uses less Z per unit of F can lead to I_2. A Hicks-neutral productivity increase in the first stage (lower cost per unit of gross output F that shifts the unit isoquant to the left) combined with the I_2 second stage technology can result in the I_3 technology. Non-neutral productivity changes in both stages can also lead to I_2 and I_3.

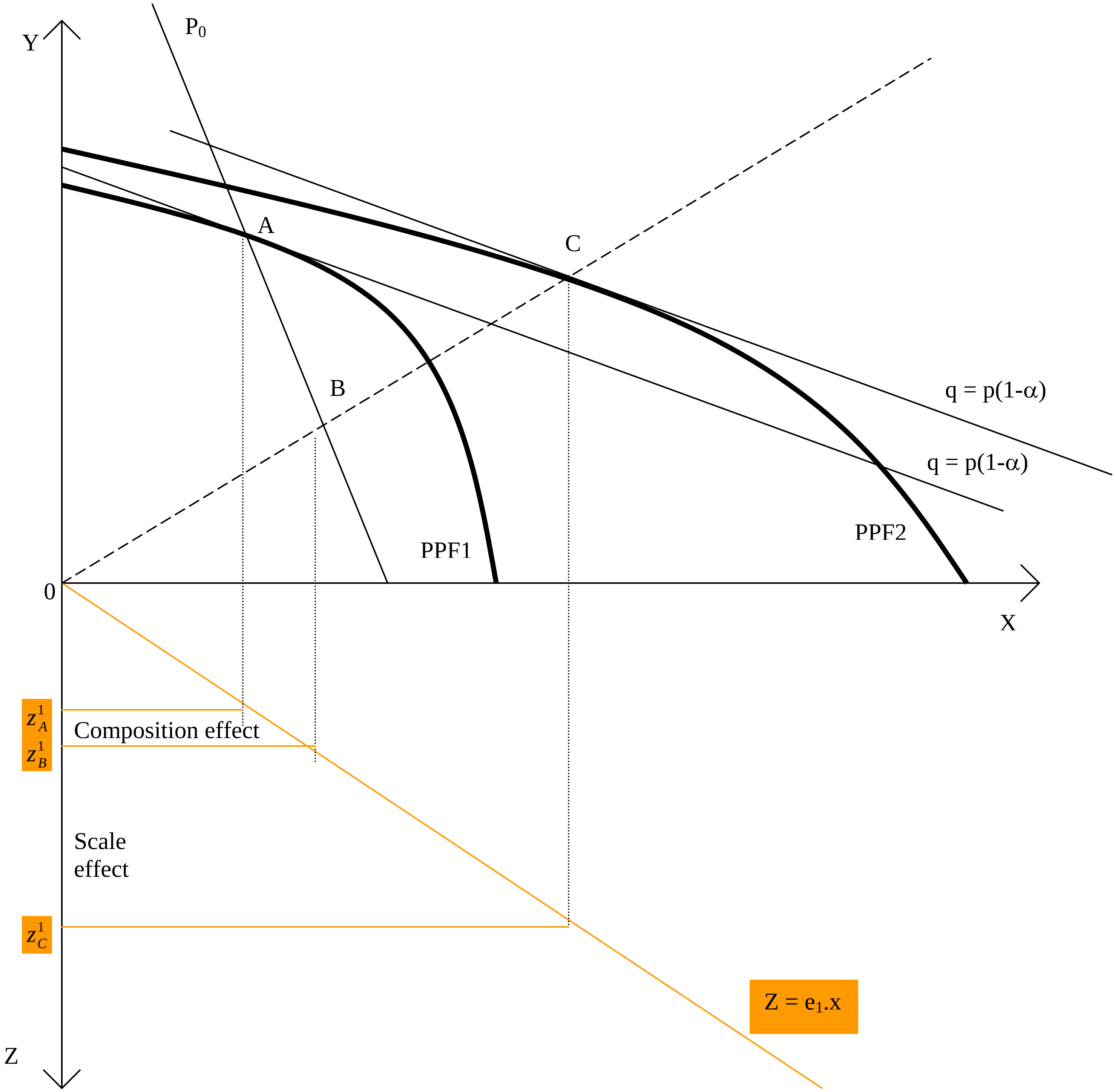

Figure 3: Scale and Composition effects with inflow of capital [Copeland and Taylor, 2003].
PPF1 is the production possibility frontier before trade liberalization and PPF2 after X-biased capital inflow. P_0 is the world price of X relative to the price of Y (Y is the numeraire good, P^Y=1). e_1 is the emissions intensity of X with the indigenous (old) technology. A to B isolates the pure composition effect, and B to C the pure scale effect. In the bottom part of the figure, the pure composition effect is z_A^1 z_B^1 and the pure scale effect is z_B^1 z_C^1.

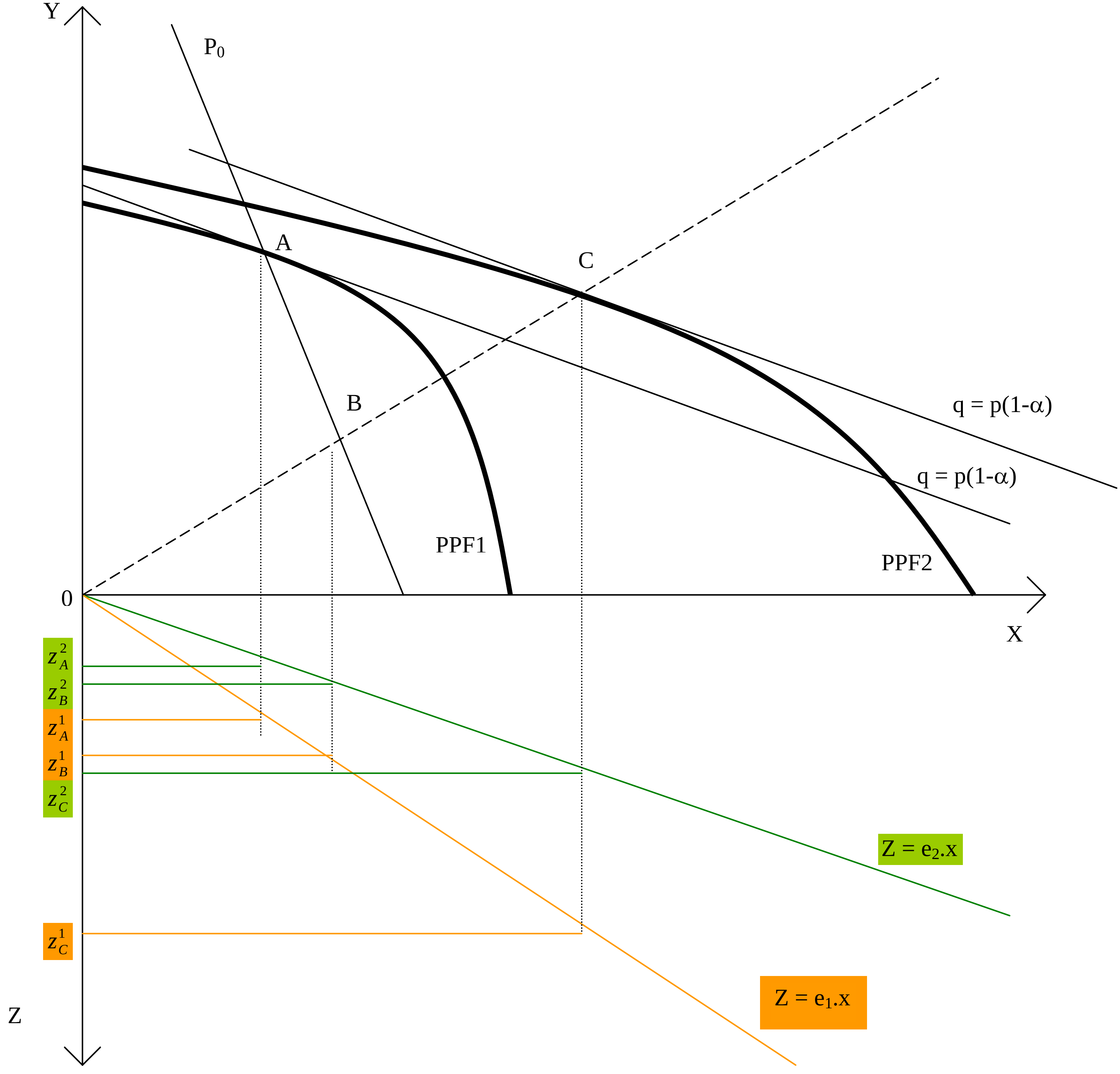

Figure 4: Porter Hypothesis: Inflow of "cleaner" FDI: Composition, Scale and Technique effects

See notes to Fig. 3. Here, e_2 is the emissions intensity of X with the fdi (new) technology. With the new technology the pure composition effect is $z_A^2\ z_B^2$ and the pure scale effect is $z_B^2\ z_C^2$. Both are smaller, with the difference being due to the Technique effect.