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Abstract

There is an important number of countries where local content requirements and carbon pricing policies are employed to address environmental degradation and develop industry. The literature has somewhat explored the role of emission taxes and local content requirements on the reduction (increase) of emissions (foreign direct investment), but not the effects on total income. I derive conditions under which laxer local content requirements and negligible adjustments in taxation reduce (increase) total emissions (income) as long as (i) free-entry effects are large and (ii) foreign direct investment (FDI) represents a large share of income. However, adjustments in the emission tax do not necessarily yield analogous results even in the presence of large entry incentives for FDI. The analysis contributes to the literature which examines the role of environmental policy on free-entry markets.

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1. Introduction

There is an important number of countries where local content requirements and carbon pricing policies are employed to address environmental degradation, create local jobs and meet national energy objectives (e.g., UNCTAD 2014, Blackman and Harrington 2000). Surprisingly, the literature has not explored, except for Gautier (2017), the combined effects of emission taxes *and* local content requirements[1] on emissions and foreign direct investment (FDI). This note examines the role of emission taxes and the local content in lowering emissions via FDI (pollution halos) and raising income in the presence of large entry effects.

The pollution halo hypothesis posits that the inflow of FDI (and arguably advanced technology and low polluting firms) decreases pollution (e.g., Aydemir and Zeren 2017, Neumayer 2001, Zarsky 1999). The inflow of FDI, in turn, arguably aids in the development of industry and creation of local jobs. With these in mind, the contribution of this note is threefold. First, it contributes to the analysis in Gautier (2017) where the author shows that laxer local content requirements attracts less polluting and more efficient foreign firms (FDI) and, as a result, emissions fall but *total* income (where FDI represents a share) may rise or fall. In particular, I derive conditions, under which not only FDI rises via laxer local content requirements, but so does total income, while achieving lower emissions. The key here is that entry incentives for more efficient and less polluting FDI are large, where the share of local jobs, dependent upon FDI, is large (i.e., local content requirements are large). To derive results a new necessary and sufficient condition is derived whereby total income rises with laxer local content requirements.

Second, the literature has shown conditions where FDI rises (e.g., Gautier 2017b, Dijkstra *et al.* 2011) and emissions fall (e.g., Lahiri and Symeonidis 2017, 2007) via higher emission taxes. I add to this literature by deriving conditions under which lower emissions and, at the same time, higher *total* income are *not* obtained via higher taxation even in the presence of large entry incentives for less polluting and more efficient FDI. There are two effects at play, namely, the effects on emissions and income via changes in the tax, and the degree of pollution intensity of the industry. Suppose the industry is pollution intensive. In this case emissions and income fall with higher taxation, and since the industry is pollution intensive then the entry of FDI aids further in the reduction of emissions because FDI is sufficiently low-polluting vis-à-vis the industry. Income, however, does not rise as FDI enters the industry since the gains in income through FDI do not compensate the losses from home firms. Thus, in the case where industry is pollution intensive emissions and income do not fall and rise, respectively. A similar result applies if the industry is not too pollution intensive, but in this case the entry of FDI, and its ability to reduce emissions, is limited because FDI is not sufficiently less polluting vis-à-vis the industry. The analysis suggests that, regardless of whether industry is pollution intensive or not the entry of FDI via higher taxation does

[1] In its more explicit form local content requirements establish the portion of locally-sourced goods and services (e.g., amount of man hours), for a given industry, that foreign firms must use. Specific examples, directly related to this note, include stipulations on the number of employees from local labor markets that foreign firms are required to meet. Industry examples include the energy industry in countries such as Ghana, Brazil and Nigeria where local content requirements (e.g., use of local inputs) have been implemented (UNCTAD 2014).

not yield higher income and lower emissions.

In contrast to higher taxation, there are cases where lower taxes are aimed at lowering emissions and raising income. The analysis suggests, however, that a downward adjustment in the tax raises income and emissions. Indeed, if the industry is not too pollution intensive, then entry of FDI does not aid enough in the reduction of emissions and so emissions do not fall with lower taxation. Along with results in the preceding paragraph, this implies that in not-too-pollution-intensive industries either higher or lower taxation is not consistent with pollution halos and the creation of sufficient local jobs via FDI. However, it is argued that with lower taxation emissions could fall and income rise if the local content is large and the industry is pollution intensive so that the entry of FDI results in a sufficient reduction in emissions. Third, this note contributes to a strand in the literature which examines environmental policy under free entry (e.g., Matsumura and Okumura 2014, Lee 1999, Katsoulacos and Xepapadeas 1995) by examining the effects of the emission tax and local content on emissions and income via FDI in the presence of large free entry effects.

2. The Model

The model relies on Gautier (2017). Here I just spell out the main components of the model. There is a fixed number of home firms, n, and an endogenous number of foreign firms, m (i.e., FDI). Home and foreign firms operate in the home country. The government in the home country and firms play a two-stage game where the government first sets an emission tax and local content requirement simultaneously. Firms then compete in a Cournot-Nash fashion for the production of a homogeneous good taking policy as given. The model is solved through backwards induction.

2.1 Firms

This section characterizes firm behavior, spells out key comparative statics results along with the implications behind large entry effects (to be used in section 3). Each home firm $i = 1, 2, \ldots, n$, and foreign firm $j = 1, 2, \ldots, m$ maximizes profits by choosing the level of output and emissions simultaneously in a Cournot-Nash fashion: $\max_{q_l^z e_l^z} \pi_l^z = (p_l^z - c_l^z)\, q_l^z - (\theta_l^z q_l^z - e_l^z)^2/2 - e_l^z t - f_l^z$, for firm $l = i, j$, from country $z = h, f$. And where q_l^z denotes output for each firm $l = i, j$ from country $z = h, f$; θ_l^z captures pollution intensity and $e_l^z = \theta_l^z q_l^z - a_l^z$ gross pollution minus abatement, a_l^z. The term p_l^z denotes the linear and downward-sloping demand function, and f_l^z denotes fixed costs. Free entry/exit of foreign firms is characterized by the zero-profit condition, $\pi_j^f = 0$. Moreover, the government in the home country commands foreign firms to employ a share $\delta \in (0, 1)$ of home inputs. By assumption home inputs are relatively less efficient i.e., $k_i^h > k_j^f \; \forall i, j$, where $k_i^h (k_j^f)$ denotes constant marginal cost of each home (foreign) firm if it employs all its inputs from the home (foreign) country. Therefore, c_l^z denotes constant marginal cost, where $k_i^h = c_i^h > c_j^f = (1-\delta)k_j^f + \delta k_i^h$. Pollution abatement costs exhibit the following structure: $(\theta_l^z q_l^z - e_l^z)^2/2$. Maximization of π_l^z, along with $\pi_j^f = 0$, yields the symmetric Cournot-Nash equilibrium, q^h,

e^h, q^f, e^f, m.

Comparative statics analysis indicates that at $\theta^h = \theta^f$ (i.e., equally pollution intensive firms-the relevance of $\theta^h = \theta^f$ is explained in section 2.2) $q_t^h < 0$, $q_t^f < 0$ and $q_\delta^f = 0$, $q_\delta^h > 0$, $m_\delta < 0$, where subscripts denote partial derivative. Importantly, $m_t > 0$: the number of foreign firms (FDI) rises with an increase in the emission tax as long as the entry incentives via the pollution abatement induced by the tax are large. Moreover, at $\theta^h = \theta^f$ and still in the presence of large entry incentives for foreign firms, total emissions, $E^T = E^h + E^f = ne^h + me^f$, fall with the emission tax, $E_t^T < 0$. And total emissions rise with the local content, $E_\delta^T > 0$, because the reduction in the number of foreign firms via an increase in the local content, $m_\delta < 0$, and thus the reduction in total abatement, is sufficiently large so that total emissions rise. I shall rely on the case where entry incentives are large. Relevant results for the present analysis are summarized in the following remark.

Remark 1. *At $\theta^h = \theta^f$ (i) $m_t > 0$ and (ii) $E_\delta^T > 0$ as long as entry incentives via the abatement induced by the tax are sufficiently large.*

2.2 Welfare

This section spells out the rationale behind policy adjustments (to be used in section 3) arising from exogenous changes in pollution intensities. The home government simultaneously chooses the tax and local content so as to maximize welfare: $\max_{t\delta} W = n\pi^h + tE^T + I - \varphi(E^T)$, where the first term denotes total profits from home firms, the second term tax revenue from the emission tax, the third term, $I = k^h nq^h + k^h \delta q^f m$, denotes total income arising from home *and* foreign output (i.e., FDI) employing home inputs, and the fourth term damages from pollution, where marginal damages are assumed to be increasing and strictly convex. Assuming second-order conditions hold, the solution yields two first-order conditions which characterize a policy vector $t(\theta^h, \theta^f) > 0$ and $\delta(\theta^h, \theta^f) \in (0, 1)$. Starting at $\theta^h = \theta^f$, differentiation of $\partial W/\partial\delta = 0$ and $\partial W/\partial t = 0$, yields the expressions for t_{θ^h} and δ_{θ^h} (subscripts denote partial derivatives). In other words, these are the policy adjustments as home firms become relatively more pollution intensive i.e., an increase in θ^h starting at $\theta^h = \theta^f$. The analysis relies on $\theta^h = \theta^f$ as the starting point to capture the idea of relatively less pollution-intensive foreign firms. Results rely also on the assumption of not-too-inefficient home firms (i.e., $k^h < 2k^f$), which ensures that total home profits plus total income rise (fall) with a increase (decrease) in the local content. Total income, I, may fall or rise with the local content, however; I delve into this point in section 3.

Starting at $\theta^h = \theta^f$, as home firms become relatively more pollution intensive the government adjusts policy depending on how it weighs the various components of the welfare function. For instance, the government may attract FDI (since entry incentives are large) and tackle emissions by raising the tax (i.e., $t_{\theta^h} > 0$), but instead may promote total income and profits via an increase in the local content i.e., $\delta_{\theta^h} > 0$. Similarly, a reduction in the local content (i.e., $\delta_{\theta^h} < 0$) may attract FDI (but combined total income and profits fall) and lower total emissions, but a lower tax (i.e., $t_{\theta^h} < 0$) promotes total income and profits. Even though Gautier (2017) considers a myriad of policy adjustments, here I focus on the policy adjustment of one of the two policies at a time to derive clear-cut results with an emphasis on total income and total emissions (an analysis not presented in Gautier's paper).

3. Effects on Income and Emissions

In this section I show the conditions under which policy adjustments yield a combined reduction in total emissions and increase in total income as home firms become relatively more pollution intensive, particularly when free-entry effects are large. I want to show that in the case where the local content is initially large[2] (i.e., $\delta \to 1$) and industry is either pollution intensive or not too pollution intensive (i.e., $\theta^h \geq \theta^h_E$, see below), the promotion of FDI via laxer local content requirements (with little adjustment in taxation) leads to both a reduction in total emissions and an increase in total income.[3]

I then show that via taxation only (laxer or stricter taxation) it is unlikely to achieve a combined increase in total income and decrease in total emissions in not-too-pollution-intensive industries ($\theta^h \simeq \theta^h_E$). The implication is that it is not via adjustments in taxation, but a laxer local content to attract FDI, that a combined reduction in total emissions and increase in *total* income can be obtained. Moreover, higher taxation does not result in higher (lower) income (emissions) in pollution intensive industries ($\theta^h > \theta^h_E$).

Consider the change in total emissions, $E^T = E^h + E^f$, where $E^T = E^T\big(t(\theta^h, \theta^f), \delta(\theta^h, \theta^f), \theta^h, \theta^f\big)$:

$$\left.\frac{dE^T}{d\theta^h}\right|_{\theta^h=\theta^f} = E^T_t t_{\theta^h} + E^T_\delta \delta_{\theta^h} + E^T_{\theta^h} \tag{1}$$

where the first, second and third term, respectively, denotes changes in total emissions via the tax adjustment, local content adjustment, and changes in emissions for given tax and local content. Additionally, $E^T_t < 0$ and $E^T_\delta > 0$ by remark 1. Following Gautier (2017), the third term in (1) is strictly concave in θ^h:

$$E^T_{\theta^h}\big|_{\theta^h=\theta^f} \leq 0 \Leftrightarrow \theta^h \geq \theta^h_E \tag{2}$$

That is, starting at $\theta^h = \theta^f$ an increase in θ^h renders foreign firms relatively less polluting and more cost competitive particularly in industries which are pollution intensive ($\theta^h > \theta^h_E$), thereby inducing a strong entry effect and reduction in emissions. If on the other hand θ^h is not too large ($\theta^h \simeq \theta^h_E$), then the industry is not too pollution intensive and so the emissions-reducing effects via the entry of foreign firms is small.

Total income is defined[4] as $I = nk^h q^h + k^h \delta q^f m$, where the first (second) term denotes

[2] Examples of large local content requirements include the objective of Brazil's Petrobras to create 100,000 jobs and use 65% of equipment services from domestic suppliers. And South Africa's local content requirements for job creation in the green energy sector is expected to rise with an 80% target within local content criteria (UNCTAD 2014, pp. 8 and 23).

[3] As an example, in South Africa this result is applicable to the energy sector (pollution-intensive sector) where steps have been taken to promote renewables (wind production) with an existing and expected large local content (50%-80% job component). The policy implication is that the sector may experience sufficient job creation (higher income) and lower emissions from a slight reduction in the local content to attract FDI.

[4] This definition is used in e.g., Gautier (2017) and Lahiri and Ono (1998).

the income coming from home (foreign) firms. Differentiation gives

$$\left.\frac{dI}{d\theta^h}\right|_{\theta^h=\theta^f} = I_t t_{\theta^h} + I_\delta \delta_{\theta^h} + I_{\theta^h} \tag{3}$$

where at $\theta^h = \theta^f$, $I_t < 0$ and $I_{\theta^h} = -k^h tn(1-\delta)\beta < 0$. The latter term denotes the change in income, for given tax and local content, and it is negligible with a large local content i.e., $I_{\theta^h} \to 0$ as $\delta \to 1$. This is because with sufficiently large local content the increase in the number of foreign firms (and thus income) that takes place via an increase in the intensity coefficient, θ^h, (i.e., foreign firms become relatively more cost competitive) offsets the reduction in home output (and thus income) as home firms become more pollution intensive. With large δ the term I_{θ^h} is negligible regardless of whether industry is pollution intensive. I shall restrict the discussion to large values of δ.

Furthermore, the sign of I_δ is ambiguous; this is because changes in the local content have opposing effects on home output and foreign firms. But if the local content is sufficiently large total income rises with a small decrease in the local content: the increase in foreign firms and thus income completely offsets the reduction in home output. That is,

$$I_\delta|_{\theta^h=\theta^f} < 0 \Leftrightarrow \frac{1}{2(k^h-k^f)\beta}\left(\frac{\alpha-k^f-\theta t}{\beta} - q^f(n+1)\right) = \hat{\delta} < \delta \tag{4}$$

where $(\alpha - k^f - \theta t)/\beta - q^f(n+1) > 0$ from the non-negativity of output, mq^f. It is noteworthy that the condition in (4) is consistent with $\delta \to 1$, which is a prerequisite for $I_{\theta^h} \to 0$ in (3). The condition in (4) is new to the literature.

Using (1), (2), (3), (4) and remark 1 the following propositions, and main results are stated formally.

Proposition 1. *Let $\theta^h \geq \theta^h_E$ and $\delta \to 1$. Consider an increase in θ^h. Then, starting at $\theta^h = \theta^f$ a reduction in the local content (i.e., $\delta_{\theta^h} < 0$) to promote FDI, along with a negligible adjustment in the tax (i.e., $t_{\theta^h} \simeq 0$), lowers total emissions (i.e., $E^T_\delta \delta_{\theta^h} < 0$) and increases total income (i.e., $I_\delta \delta_{\theta^h} > 0$).*

Proposition 2. *Let $\theta^h \simeq \theta^h_E$. Consider an increase in θ^h. For any $\delta \in (0,1)$, starting at $\theta^h = \theta^f$ either a decrease or increase in the emission tax (i.e., $t_{\theta^h} < 0$ or $t_{\theta^h} > 0$), along with a negligible adjustment in the local content (i.e., $\delta_{\theta^h} \simeq 0$), does not yield a combined reduction in total emissions and increase in total income.*

Proposition 3. *Let $\theta^h > \theta^h_E$. Consider an increase in θ^h. For any $\delta \in (0,1)$, starting at $\theta^h = \theta^f$ an increase in the emission tax to attract FDI (i.e., $t_{\theta^h} > 0$), along with a negligible adjustment in the local content (i.e., $\delta_{\theta^h} \simeq 0$), does not yield a combined reduction in total emissions and increase in total income.*

The intuition of proposition 1 is that in the presence of large entry effects (due to abatement incentives, $E^T_\delta > 0$) and large local content (large share of local resources used by FDI), a laxer local content induces a sufficiently large entry of FDI and thus income. The emissions-reducing effect via FDI is large (small) if the industry is (not) pollution intensive, $\theta^h > (=)\theta^h_E$. The implication is that in industries where FDI employs a large share of local resources a slight reduction in the local content translates into higher/lower income/emissions. Proposition 2 says that no matter which way the tax is adjusted, a *combined* increase/decrease in income/emissions is not possible, particularly when industry is not too pollution intensive ($\theta^h \simeq \theta^h_E$) where the ability of FDI to lower emissions is less. In contrast to proposition 1, proposition 2 does not require conditions for the size of the local content, but it states a threshold pollution intensity. Propositions 2 and 3 imply that regardless of the degree of pollution intensity of the industry higher taxation to attract FDI does not lower emissions and raises income. Now, in the case where the industry is pollution intensive ($\theta^h > \theta^h_E$) a tax reduction could increase income (if δ is large) and lower emissions via the third term in (1) since in this case the entry of FDI induces a substantial reduction in emissions. But a result like this requires additional restrictions on the concavity of the third term in (1) which controls emissions, not the tax adjustment.

4. Final Remarks

Conditions consistent with the pollution halo hypothesis and gains in income via FDI appear to be somewhat restrictive. Local content requirements need to be large, home firms cannot be too inefficient and entry incentives via the abatement induced by the tax need to be large as well. This latter condition may be the most restrictive from a policy standpoint. The reason is that large entry effects via the long-run incentives the emission tax offers rely on innovation. However, there are cases where emission taxes have been implemented partly because of the entry incentives they offer arising from technological innovation (Tietenberg 2013). Under the aforementioned conditions a policy design can be used to seek a resource allocation consistent with pollution halos, but also guide empirical analyses, particularly in cases where the local content plays a key role. It is noteworthy that the analysis relies on changes in one policy while holding the other policy constant. A natural extension is to explore conditions whereby a change in both policies yields higher income and lower emissions. For instance, a tax increase lowers emissions and income, but if this policy change is coupled with a reduction in the local content, then the income-increasing effect via the local content can potentially offset the reduction in income coming from the tax. Another potential extension would be to add consumer surplus effects into welfare analysis; this would likely change policy adjustments and potentially results in section 3, particularly if the government puts sufficient weight on consumer surplus effects.

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