Competitive Pressure & Emission-reducing Innovation

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A Toxa, June 21, 2018

Motivation

- Reducing emission-intensity is key for any solution to climate change
- Huge literature, mainly assuming static, atomistic market structure
- Compliance costs of regulated firms generate incentives to reduce costs
- But climate policy often operates in markets with imperfect competition (Fowlie, Reguant & Ryan, 2016)
- How does the market structure and its interaction with regulation affect innovation incentives?

This paper

- Linking innovation and competition leads to novel insights on the efficiency of unilateral environmental policy instruments
- Shows the effect of policy on innovation under an endogenous market structure with heterogenous industries:
- Within industries firms with different costs compete à la Cournot (plus entry and exit) and choose innovation effort
- Changes in market structure induced by changes in comparative advantages render incentives for process innovation
- Unilateral policy increases productivity of average domestic firm, reduces domestic markups, causes domestic exit and foreign entry

Consumers

There are two (first symmetric) countries $r \in \{d, f\}$. Later, d will increase pollution price.

Households have CES preferences: $U_r = \left(\int_{j \in \omega} x_{jr}^{\alpha} dj \right)^{\frac{1}{\alpha}}$

with elasticity of substitution between varieties of $\sigma = 1/(1-\alpha)$ with $\alpha \in (0, 1)$.

Production and innovation

- In each region r, any variety j is produced by at least one firm, and products from different regions are perfectly substitutable
- Varieties can be identified by their underlying productivity and are drawn from a Pareto distribution

Production:

$$\begin{aligned} \hat{q}_{jr} &= e_{jr}^{\gamma}(z_{jr}^{\eta} l_{jr})^{1-\gamma} \\ c_{jr} &= t_r^{\gamma}\left(\frac{w_r}{z_{jr}}\right)^{1-\gamma} \end{aligned}$$

with endogenous productivity: $z_{jr} = \tilde{z}_j h_{jr}$

Market and competition

- In each variety $\sum_r n_r$ firms compete: $x_r = \sum_s n_s q_{sr}$. Firms are "large in the small, but small in the large".
- There are iceberg transport costs $\tau_{rs} \geq 1$. Thus, $\hat{q}_r = q_{rr} + \tau_{rs} q_{rs}$
- Firm's problem:

$$\underset{q_{rd}, q_{rf}, h_r}{\text{Max}} \; \Pi_r = \sum_s (p_s - \tau_{rs} c_r(z, w_r, t_r)) q_{rs} - w_r(h_r + \lambda_r)$$

s.t.
inverse Marshallian demand:

$$p_s = \frac{E_s}{X_s^\alpha} x_s^{\alpha - 1}$$

with $E_s = \int_0^{M_s} p_s(z) x_s(z) dz$

Product market equilibrium under Cournot

Cournot equilibrium quantities:

$$q_{rs} = \frac{x_s}{1-\alpha}\left[1 - \vartheta_{rs}\left(\frac{\sum_{rr} n_{rr} + \alpha - 1}{n_r}\right)\right] \quad (1)$$

where $\vartheta_{rs} = \frac{\tau_{rs} n_r c_r}{\sum_{rr} c_{rr} \tau_{rr,s} n_{rr}}$

Pricing:

$$p_s = \frac{\tau_{rs} c_r}{\theta_{rs}} = \frac{\sum_{rr} n_{rr} \tau_{rr,s} c_{rr}}{\sum_{rr} n_{rr} + \alpha - 1} \quad (2)$$

with $\theta_{rs} = \vartheta_{rs}\left(\frac{\sum_{rr} n_{rr} + \alpha - 1}{n_r}\right)$

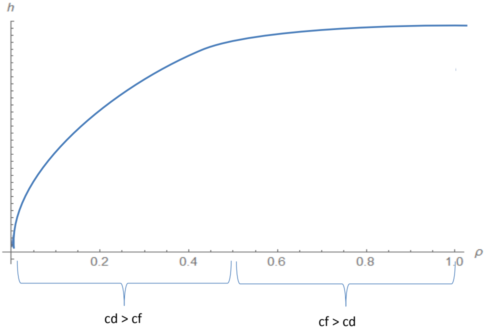
Market share: $\rho_{rs} = \frac{1-\theta_{rs}}{1-\alpha}$

Profit-maximizing innovation effort

FOC: $-\frac{\partial c_r}{\partial h_r}\hat{q}_r = w_r$

Then:

$$h_r = \eta(1-\gamma)\frac{c(\tilde{z})_r}{w_r}\hat{q}(\tilde{z})_r \tag{3}$$



Entry & exit of firms and varieties

- n_r identical firms produce $M \in [0,1]$ varieties in country r.
- Both M_r and n_r are endogenous variables characterize two margins of entry.

Free entry condition:

$$\left(\sum_s \left(\frac{\tau_{rs}}{\theta(\tilde{z})_{rs}} - 1 \right) c(\tilde{z})_r q(\tilde{z})_{rs} \right) - w_r \left(h_r(\tilde{z}) + \lambda \right) = 0 \qquad (4)$$

$$n(\tilde{z})_r \geq 1 \qquad (5)$$

Aggregation and equilibrium

$$\text{Demand: } x_r = (p_r/P_r)^{-\sigma}(E_r/P_r) \quad (6)$$

$$\text{Labor Market Clearing: } LL_r = \int_M n_r\left(ld_r\hat{q}_r + h_r + \lambda\right)dj \quad (7)$$

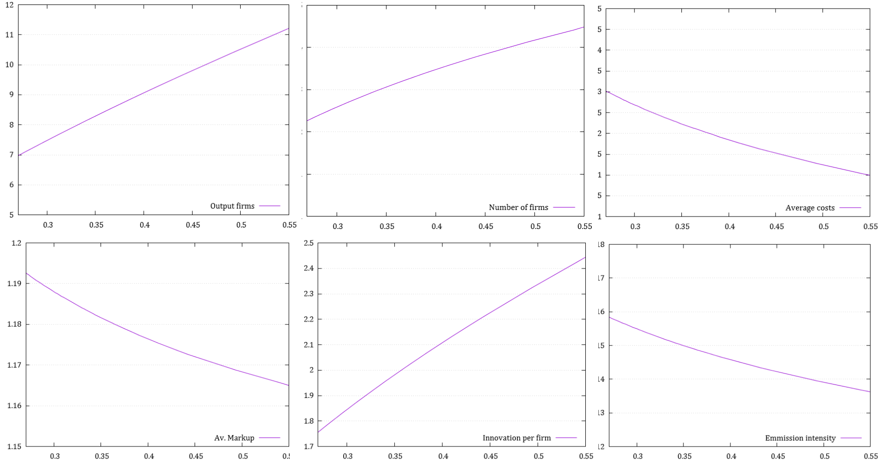
Solve system of equation for $\{q_{rs}, p_{rs}, h_r, n_r, M, x_r, w_r\}$

Calibration

σ	Elasticity of substitution	3.8	Bernard et al. (2003)
γ	Emission value share	0.01	Shapiro & Walker (2018)
η	Elasticity of innovation f.	0.17	Impullitti et al. (2017)
ω	Lower bound Pareto distr.	0.2	Bernard et al. (2007)
κ	Shape of Pareto distr.	3.4	Bernard et al. (2007)
τ_{rs}	Iceberg transport cost	1.2	Impullitti et al. (2017)
λ	Fix cost of establishment	0.33	Impullitti et al. (2017)

Table: Parameter

Symmetric benchmark



Average effects

Increase of t_d by 50%.

	d	f
Δ Average emission intensity	-10.19%	11.86%
Δ Average productivity	0.29%	-0.28%
Δ Average R&D expenses	1.76%	-1.65%
Δ Average number of firms	-1.61%	1.56%
Δ Average output per firm	0.14%	0.03%
Δ Average markup	-0.18%	0.17%

Simple decomposition

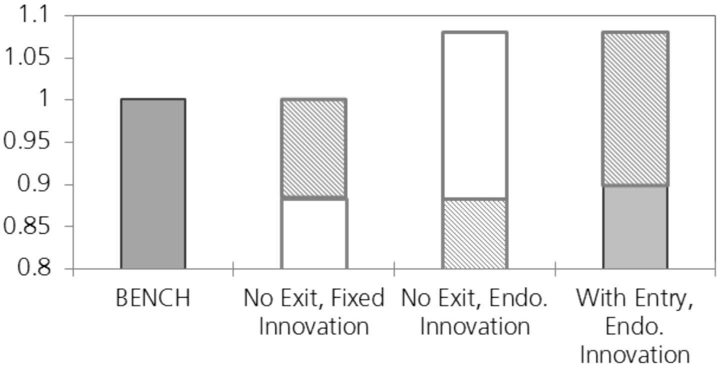


Figure: Decomposition change in emission intensity.

Conclusions

- Develops a general equilibrium model with heterogeneous industries in which firms compete à la Cournot, endogenous market structure and process innovation
- Reveals interaction between induced comparative advantages, market structures and innovation.
- Unilateral policy increases productivity of average domestic firm, reduces domestic markups, causes domestic exit and foreign entry
- To do: Improve calibration
- So far ignored innovation spillover (across firms, industries, countries)

Thank you for your attention!

Funding from European Commission's 7th FP (Project ENTRACTE) and the Robert Bosch Foundation is gratefully acknowledged.

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