How do environmental policies affect green innovation and trade?

New evidence from the WTO Environmental Database (EDB)*

Francesco S. Bellelli[2], Ankai Xu[1]

[1]Research economist, WTO

[2]Quantitative analyst, UBS

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Motivation

- Increase use of industrial policies to address environmental challenges
- A lack of cross-country information on the use and magnitude of environmental polices
- The domestic and international impacts of these policies are little understood

Contribution

The paper has the following two objectives:

- Extract information from the WTO environmental database (EDB) to make it more accessible to economic research
- Study how environmental measures impact green innovation and trade in environmental goods

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Data - WTO Environmental Databas

- The WTO Environmental Database (EDB) contains over 14000 environment-related measures notified to the WTO from 2009 to 2020
- For each policy, the database contains a description of the measure and information on the economic sector, the type of instruments used and the environmental goal pursued by the policy.
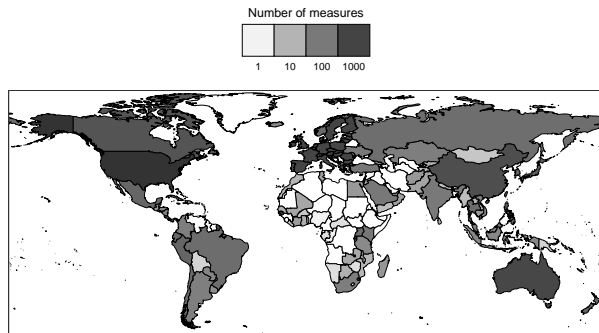

Figure: Number of notified measures by country

Data Extension

We make information more accessible for economic research by:

- Extracting the implementation years of policy measures
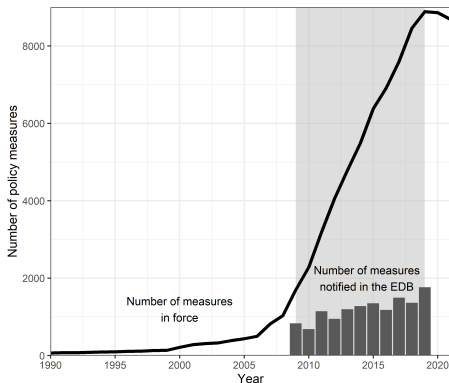

Figure: Number of active policy measures detected in the EDB

Data Extension

We make information more accessible for economic research by:
- Extracting the implementation years of policy measures
- Identifying products affected by the policy measures and link them to HS chapters.
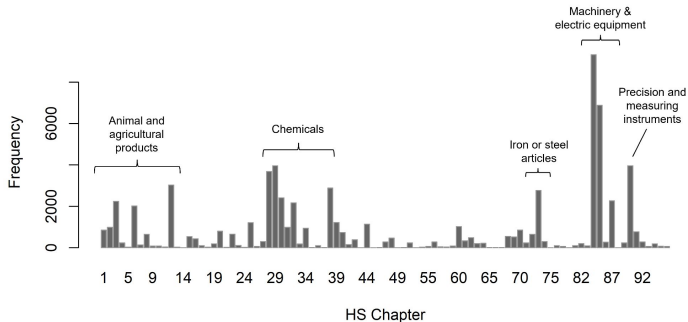
Figure: Detected products targeted by EDB measures

Data Extension

To link EDB measures to HS codes:

- Step 1: Extract and clean keywords
- Step 2: Link policy measures and HS chapters `details`
- Step 3: Incorporate info from the harmonized sectors & objectives `details`
- Step 4: Link ICS codes with HS codes
- Step 5: Calculate relative link strength `details`
- Step 6: Reducing the number of links `details`
- Step 7: Calibrating cut-off value for parameters `details`

Data Extension

We categorize policy measures into two groups: *REG* measures and *SUB* measures.

Figure: Frequency of instruments used in REG and SUB measures
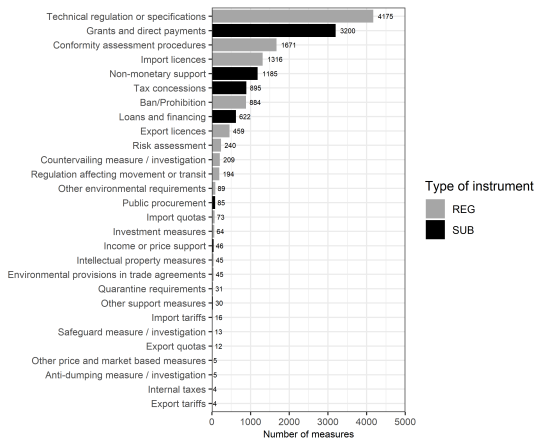
Data Extension

We develop an index to measure the strength of each policy measure

$$Score_i = Breadth_i \times Depth_i$$

Where

$$Breadth_i = 1.5 \cdot sectors_i + 0.75 \cdot (objectives_i + keywords_i)$$
$$Depth_i = wording_i + variety_i + type_i \quad \text{details}$$
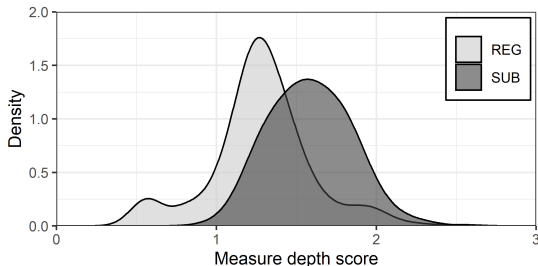
Figure: Measure score distribution for two groups of policy measures

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Research question

- Environmental policy can be used to direct the economy on a green growth path. A key role is played by green innovation (Acemoglu et al., 2012, 2014).

- Leveraging the EDB dataset, we evaluate how different types of environment-related measures have impacted green innovation and trade.
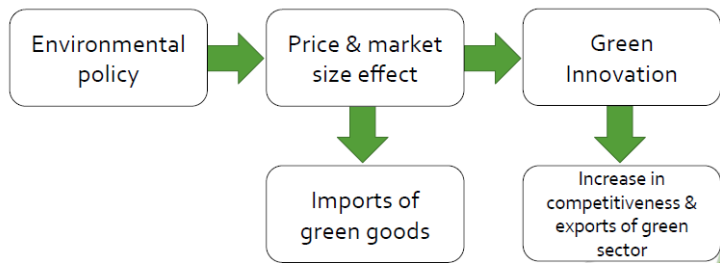
Empirical strategy

- Our strategy: comparing variation in patenting in green technologies and/or trade in green goods following environmental policies with non-green technologies and/or goods

- The policy treatment variable in country (i), sector (k) and time (t) is defined as:

$$Policy_{ikt} = \sum_{m=1}^{M} Active_{mit} \times Depth_m \times \bar{L}_{mk} \qquad (1)$$

- We experiment with different policy measurements: dummy, count, policy score

Empirical strategy

$$patent_{ikt} = \exp[\alpha_i + \alpha_k + \alpha_{it} + \beta_1 ENV_k \times \log(Policy_{ikt}) +$$
$$\beta_2 \log(Policy_{ikt}) + \gamma_1 \log(K_{ikt}) + \gamma_2 ENV_k \cdot \log(EK_{it})$$
$$+ \gamma_3 \log(\bar{X}_{ik}) + \gamma_4 \log(\bar{M}_{ik})] \cdot u_{ikt}$$

- We proxy innovation by the fractional count of patents within the triadic family
- In defining green technologies, we rely on OECD ENV-TECH lists (Haščič & Migotto, 2015) using HS-IPC conversion table (Lybbert & Zolas, 2014)

Empirical strategy

$$T_{ijkt} = \exp[\beta_1 ENV_k \times \log(Policy_{ikt}) + \beta_2 ENV_k \times \log(Policy_{jkt}) +$$
$$+ \beta_3 \log(Policy_{ikt}) + \beta_4 \log(Policy_{jkt}) + \gamma_1 \log(K_{ikt}) +$$
$$\gamma_2 \log(K_{jkt}) + \gamma_3 ENV_k \times \log(EK_{it}) + \gamma_4 ENV_k \times \log(EK_{jt}) +$$
$$\gamma_5 RTA_{ijt} + \alpha_{ij} + \alpha_{it} + \alpha_{jt} + \alpha_k] \cdot u_{ijkt}$$

- In defining green goods, we rely on the OECD Combined List of Environmental Goods (CLEG) (Sauvage, 2014).

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Results

Dependent Variables:	Innovation		Trade			
			Exporter	Importer	Exporter	Importer
	1yr lag	3yr lag	1yr lag		3yr lag	
ENV × Regulation, tax and standards	-0.001	-0.022	-0.019	0.002	-0.005	-0.001
	(0.010)	(0.015)	(0.014)	(0.014)	(0.018)	(0.002)
ENV × Subsidies and support	0.012	0.005	0.073***	-0.041**	0.061***	-0.001
	(0.018)	(0.021)	(0.016)	(0.020)	(0.018)	(0.002)
Regulation, tax and standards	-0.006	0.001	0.171***	-0.068***	0.233***	-0.010***
	(0.007)	(0.010)	(0.013)	(0.012)	(0.016)	(0.002)
Subsidies and support	-0.007	-0.004	-0.127***	0.064***	-0.135***	0.007***
	(0.008)	(0.010)	(0.013)	(0.015)	(0.015)	(0.001)
ENV × Tot stock env. patents	-0.0003	0.009	0.192***	0.016***	0.190***	0.012**
	(0.006)	(0.007)	(0.006)	(0.005)	(0.008)	(0.006)
Stock patents sector	0.974***	0.989***	0.583***	0.050***	0.590***	0.053***
	(0.007)	(0.008)	(0.011)	(0.007)	(0.013)	(0.007)
Pre-sample exports	0.038***	0.032***				
	(0.007)	(0.008)				
Pre-sample imports	-0.020**	-0.022**				
	(0.008)	(0.010)				
Country-Year FE	Yes	Yes	–		–	
Sector FE	Yes	Yes	Yes		Yes	
Exporter-Importer FE	–	–	Yes		Yes	
Exporter-Year FE	–	–	Yes		Yes	
Importer-Year FE	–	–	Yes		Yes	
Observations	176,401	109,727	4,996,420		3,552,890	
Pseudo R^2	0.931	0.931	0.821		0.821	

Results

Trade
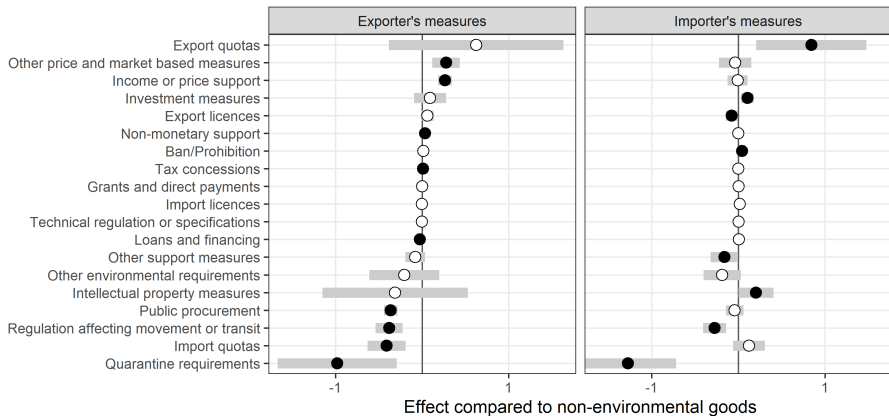
Figure: Environmental specialisation effect by type of policy instrument

Results

	GVC linkage				R&D subsidies	
	1yr lag	3yr lag	1yr lag	3yr lag	1yr lag	3yr lag
GVC linkage	0.304***	0.282***				
	(0.028)	(0.029)				
GVC forward linkage			-2.45***	-2.62***		
			(0.356)	(0.374)		
GVC backward linkage			2.73***	2.88***		
			(0.354)	(0.371)		
R&D expenditure					0.343***	0.346***
					(0.024)	(0.029)
ENV $\times$ Regulation, tax and standards	-0.004	-0.0006	-0.007*	-0.005	0.002	0.0009
	(0.004)	(0.006)	(0.004)	(0.005)	(0.005)	(0.006)
ENV $\times$ Subsidies and support	-0.031***	-0.019***	-0.026***	-0.017**	-0.005	-0.007
	(0.006)	(0.008)	(0.005)	(0.007)	(0.005)	(0.006)
Regulation, tax and standards	0.002*	0.003***	0.001	0.002	0.001	0.001
	(0.001)	(0.001)	(0.001)	(0.001)	(0.0010)	(0.001)
Subsidies and support	-0.007***	-0.006***	-0.006***	-0.005***	-0.0010	-0.001
	(0.0009)	(0.001)	(0.0010)	(0.001)	(0.0009)	(0.0009)
ENV $\times$ Tot stock env. patents	0.010***	0.009***	0.010***	0.009***	0.010***	0.010***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.002)
Stock patents sector	0.003***	0.003***	0.003***	0.003***	0.002***	0.002***
	(0.0003)	(0.0003)	(0.0003)	(0.0003)	(0.0004)	(0.0005)
Pre-sample exports	0.003***	0.003***	0.002***	0.002***	0.004***	0.004***
	(0.0006)	(0.0006)	(0.0005)	(0.0005)	(0.0005)	(0.0007)
Pre-sample imports	-0.003***	-0.003***	-0.003***	-0.003***	-0.004***	-0.004***
	(0.0005)	(0.0005)	(0.0005)	(0.0005)	(0.0005)	(0.0006)
Observations	6,368	6,368	6,368	6,368	3,836	2,840
Pseudo R^2	0.976	0.975	0.976	0.976	0.975	0.974

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Conclusion

- The paper fills the information gap on the use of trade related environmental measures over time
- We shed some light on the effects of trade-related environmental measures on innovation and trade
  - Environmental support policies (e.g. income or price support, non-monetary support) are associated with increase in exports of environmental goods relative to non-environmental ones.
  - While R&D support is positively associated with innovation, general subsidies do not have significant impact on innovation.

References

Acemoglu, D., Aghion, P., Bursztyn, L., & Hemous, D. (2012). The environment and directed technical change. *American Economic Review*, 102(1), 131–166.

Acemoglu, D., Aghion, P., & Hémous, D. (2014). The environment and directed technical change in a North–South model. *Oxford Review of Economic Policy*, 30(3), 513–530.

Haščič, I. & Migotto, M. (2015). Measuring environmental innovation using patent data. *OECD Environment Working Papers*, No. 89. Available from `http://www.oecd.org/env/indicators-modelling-outlooks/green-patents.htm`.

Lybbert, T. J. & Zolas, N. J. (2014). Getting patents and economic data to speak to each other: An 'algorithmic links with probabilities' approach for joint analyses of patenting and economic activity. *Research Policy*, 43, 530–542.

Sauvage, J. (2014). The stringency of environmental regulations and trade in environmental goods. *OECD Trade and Environment Working Papers*, 2014/03. Available from `https://dx.doi.org/10.1787/5jxrjn7xsnmq-en`.

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Data Extension

To link EDB measures to HS codes:

- Step 1: Extract and clean keywords
- Step 2: Link policy measures and HS chapters
  - For every notified measures i that share at least one key word with the HS 2-digit category j, let N_{ik} be the frequency of a keyword k in description of the measure i and N_{jk} the frequency of keywords in the HS category j. The strength of the link L is measured by:

  $$L_{ij} = \sum_{k=1}^{K_i} N_{ik} \cdot (N_{jk} \cdot \omega_k)$$

  - A weighting scheme ω gives more importance to keyword k which are specific to single HS chapter.

  $$\omega_k = 1 + \log \left(\frac{1 + J^*}{1 + J_k} \right)$$

back

Data Extension

To link EDB measures to HS codes:

- Step 1: Extract and clean keywords
- Step 2: Link policy measures and HS chapters
- Step 3: Incorporate info from the harmonized sectors & objectives

Harmonised sector	HS chapters
Specific sectors:	
Agriculture	6–14
Chemicals	28–40
Energy	84–85
Forestry	44–48
Fisheries	3
Manufacturing	15–24, 50–70, 84–96
Mining	25–27, 71–83
Other sectors:	
All products/economic activities	1–97
Not specified	1–97
Other	1–2, 4–5, 41–43, 49, 97–99
Services	—

Data Extension

To link EDB measures to HS codes:

- Step 1: Extract and clean keywords
- Step 2: Link policy measures and HS chapters
- Step 3: Incorporate info from the harmonized sectors & objectives
  - Let S_i denote the set of HS categories that match the harmonised sectors of measure i, and E_i be the set of HS chapters that are consistent with the harmonised environmental objective of measure i. Then we can introduce a weight W_{ij}^S and W_{ij}^E to adjust the link strength:

$$\tilde{L}_{ij} = L_{ij} \cdot W_{ij}^S \cdot W_{ij}^E \quad \text{with} \quad W_{ij}^S = \begin{cases} 1 & \text{if } j \in S_i \\ 0.5 & \text{otherwise} \end{cases}$$

$$W_{ij}^E = \begin{cases} 1 & \text{if } j \in E_i \\ 0.9 & \text{otherwise} \end{cases}$$

back

Data Extension

To link EDB measures to HS codes:

- Step 1: Extract and clean keywords
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- Step 3: Incorporate info from the harmonized sectors & objectives
- Step 4: Link ICS codes with HS codes
- Step 5: Relative link strength $\bar{L}_{ij}$ of each one of its links:

$$\bar{L}_{ij} = \frac{\tilde{L}_{ij}}{\sum_{j=1}^{J^*} \tilde{L}_{ij}}$$

back

Data Extension

To link EDB measures to HS codes:

- Step 1: Extract and clean keywords
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- Step 4: Link ICS codes with HS codes
- Step 5: Calculate relative link strength
- Step 6: Reduce the number of policy-HS links back
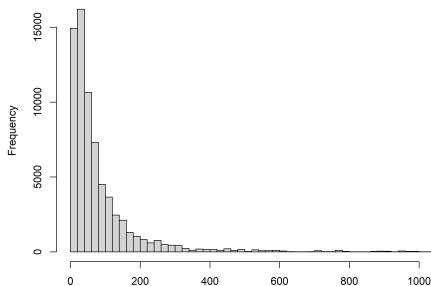
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- Step 4: Link ICS codes with HS codes
- Step 5: Calculate relative link strength
- Step 6: Reduce the number of policy-HS links
- Step 7: Calibrate cut-off value for parameters

$$\omega_k = \begin{cases} 1 + \log\left(\frac{1+J^+}{1+J_k}\right) & \text{, if } J_k \leq J^+ \\ 0 & \text{, if } J_k > J^+ \end{cases}$$

$$J^+ = 20 \quad , \quad \tilde{L}^+ \approx 9.4 \text{ (70\% quantile)} \quad \text{and} \quad \bar{L}^+ = 0.1$$

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$$wording_i = \frac{\log(1 + W_i)}{\log(1 + max(W))}$$

where:

$$W_i = \log(n_i^W) + 2\log(n_i^A) + 3\log(n_i^S)$$

n^W, n^A and n^S indicate respectively the number of weak, average and strong verbs in the descriptions of measure i.

Table: Verb grouping examples

Neutral	Weak	Average	Strong
include	promote	protect	regulate
use	support	ensure	prevent
establish	contain	provide	require
propose	encourage	improve	prohibit
make	implement	reduce	exclude

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Variety is based on the number of different policy tools that are adopted in the measure.

$$variety_i = \frac{\log(1 + M_i)}{\log(1 + max(M))}$$

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Table: Ranking of measure types

Rank	Harmonised measure type
Standards and regulations	
1	Ban/Prohibition
1	Internal taxes
2	Import tariffs
2	Export tariffs
	...
3	Technical regulation or specifications
	...
4	Risk assessment
4	Intellectual property measures
	...
Subsidies	
1	Grants and direct payments
1	Income or price support
2	Tax concessions
2	Loans and financing
	...
3	Other support measures

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