How do environmental policies affect green innovation and trade?

New evidence from the WTO Environmental Database (EDB)

Francesco S. Bellelli and Ankai Xu

EAERE annual conference - 30 June 2022

1) Introduction

2) EDB dataset

3) Research question

4) Empirical strategy

5) Results

Introduction

The paper has the following two objectives:

1. Extract information from the **WTO environmental database (EDB)** to make it more accessible to economic research

2. Studying how environmental measures impact **green innovation** and **trade in environmental goods**

Link to the paper

https://www.wto.org/english/res_e/reser_e/ersd202203_e.htm

Environmental Database

Link to the WTO environmental database (EDB)

https://edb.wto.org/

1) Introduction

2) EDB dataset

3) Research question

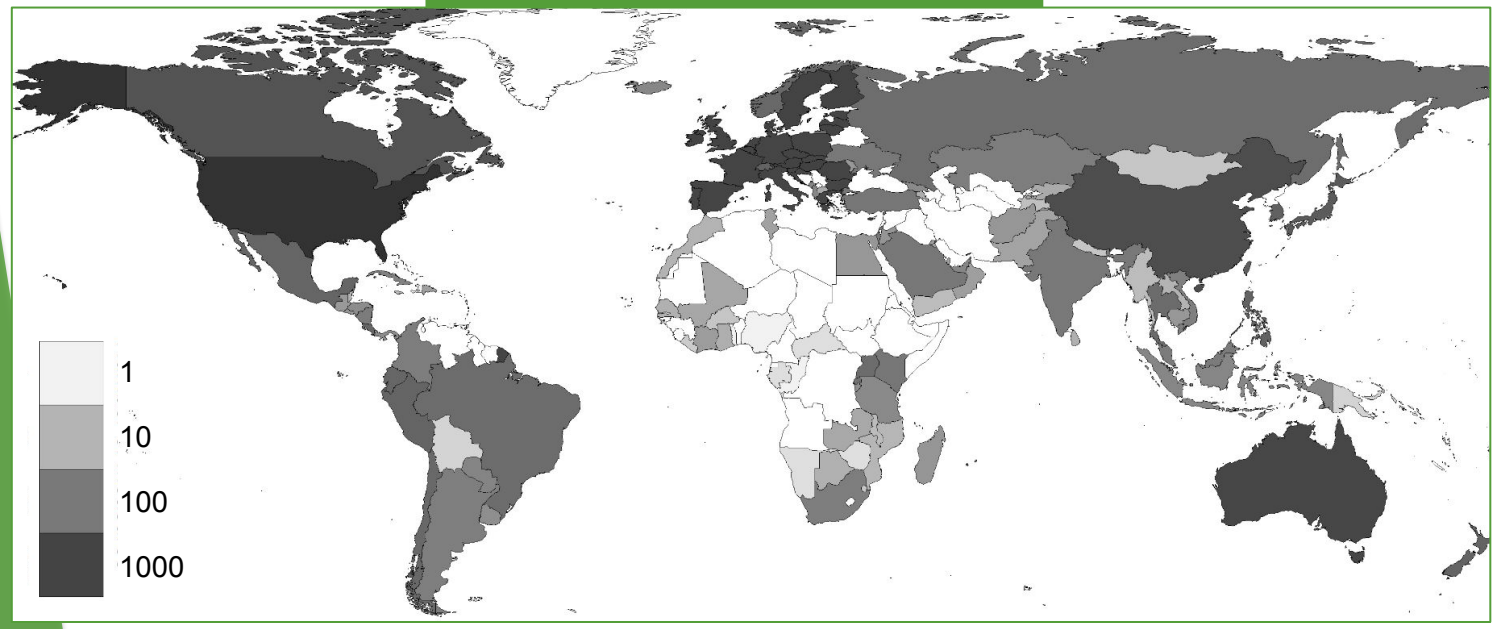
4) Empirical strategy

5) Results

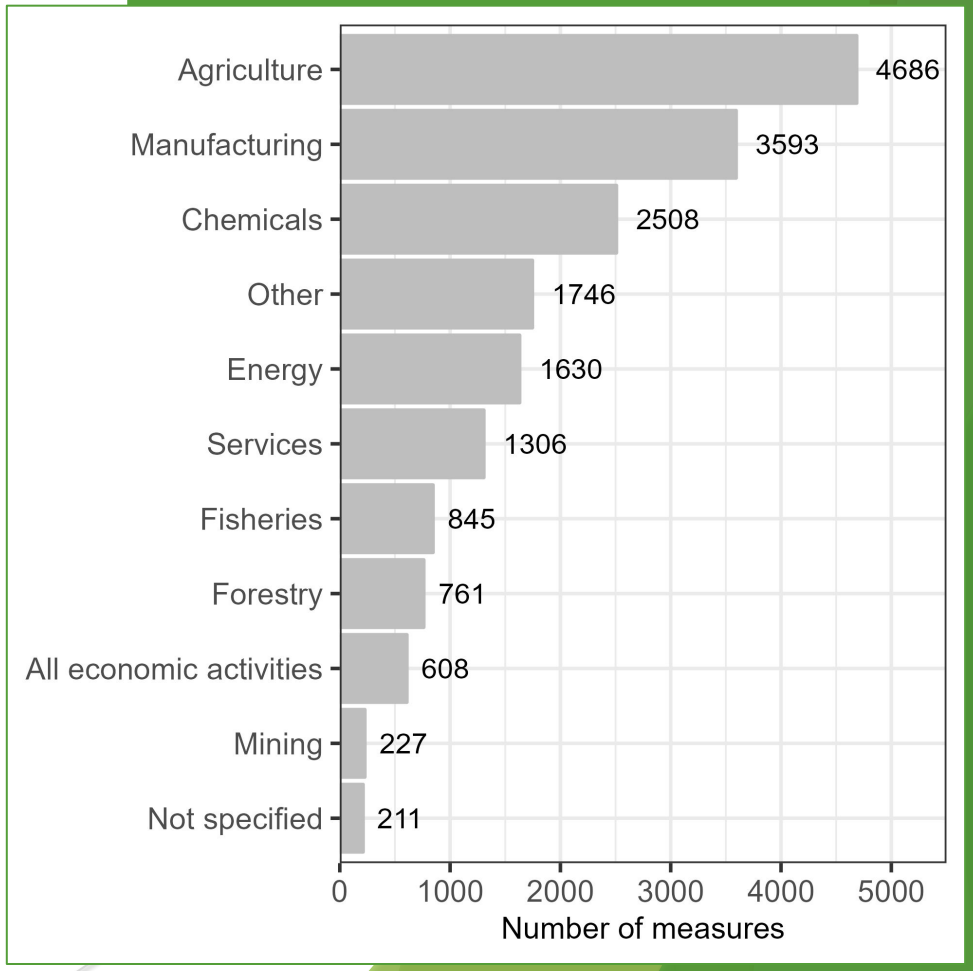
The WTO Environmental Database (EDB)

- 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.

Number of measures by country



Number of measures by sector

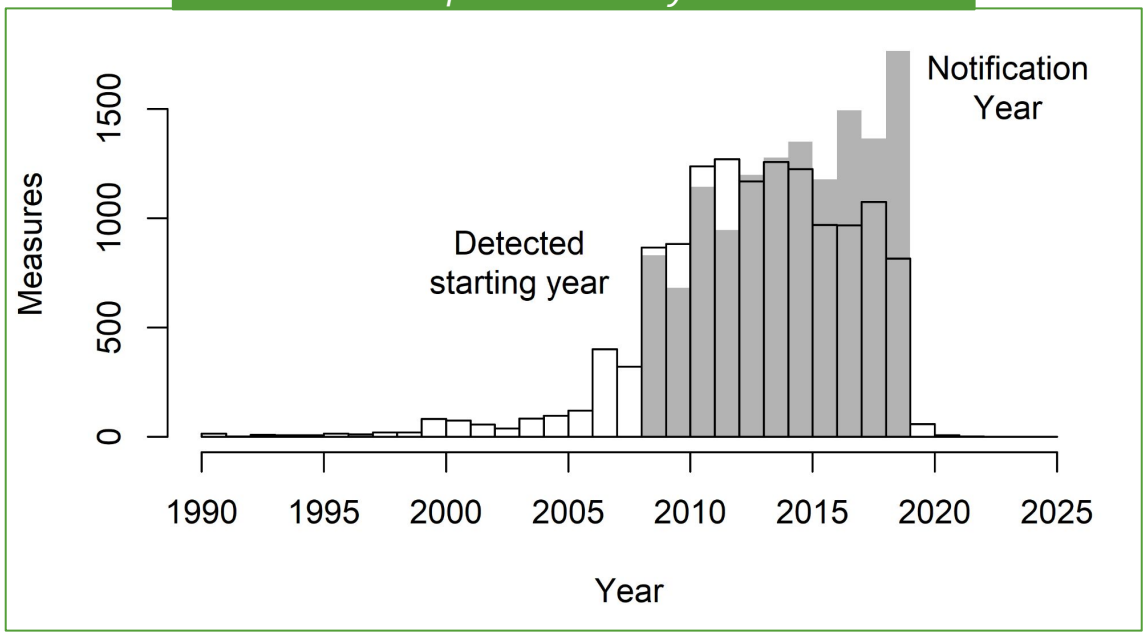


Extending the EDB for economic research

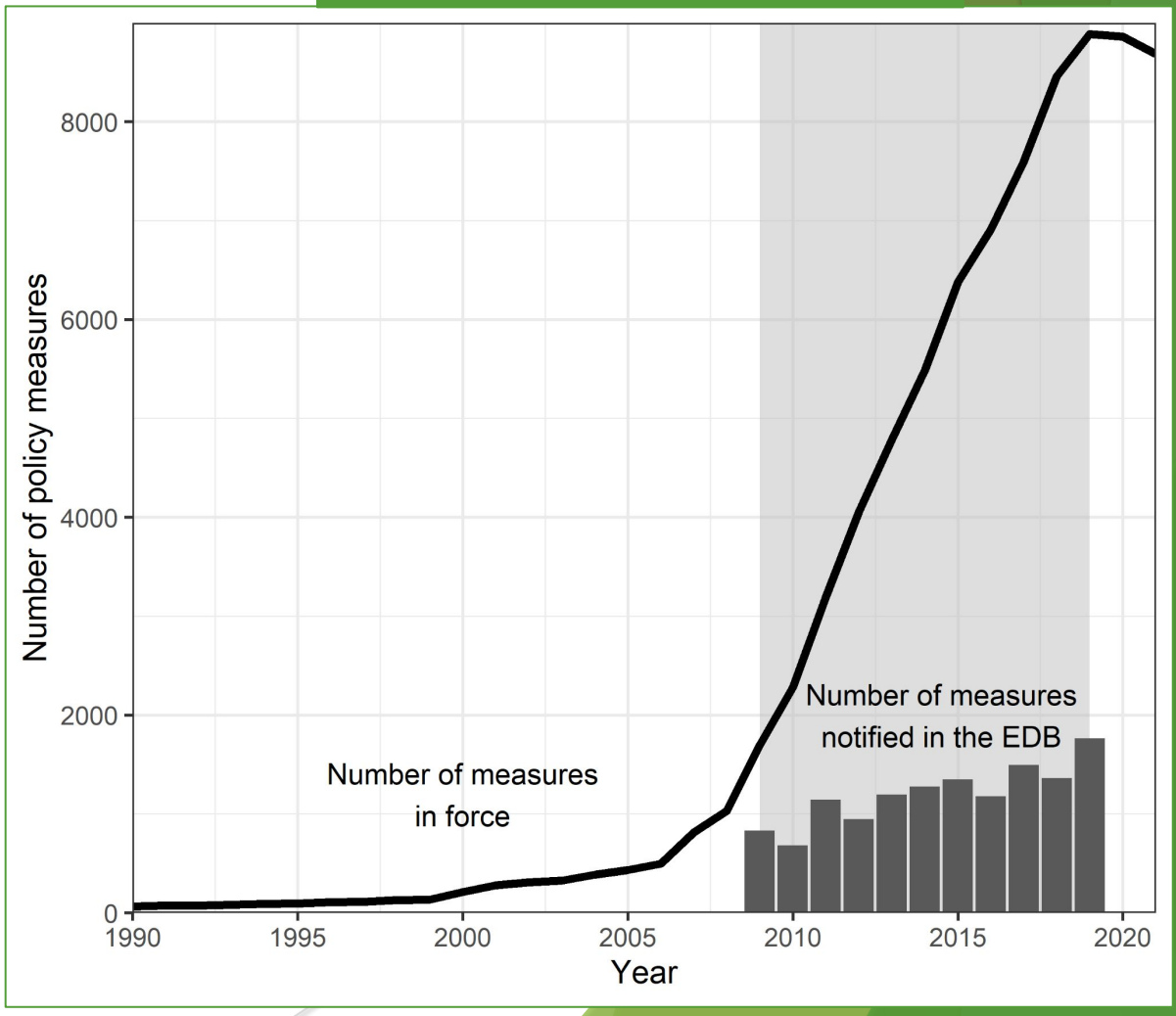
We make information in the database more accessible for economic research by:

a Extracting the **implementation years** of policy measures

Discrepancy between notification and implementation year



Notification vs implementation year

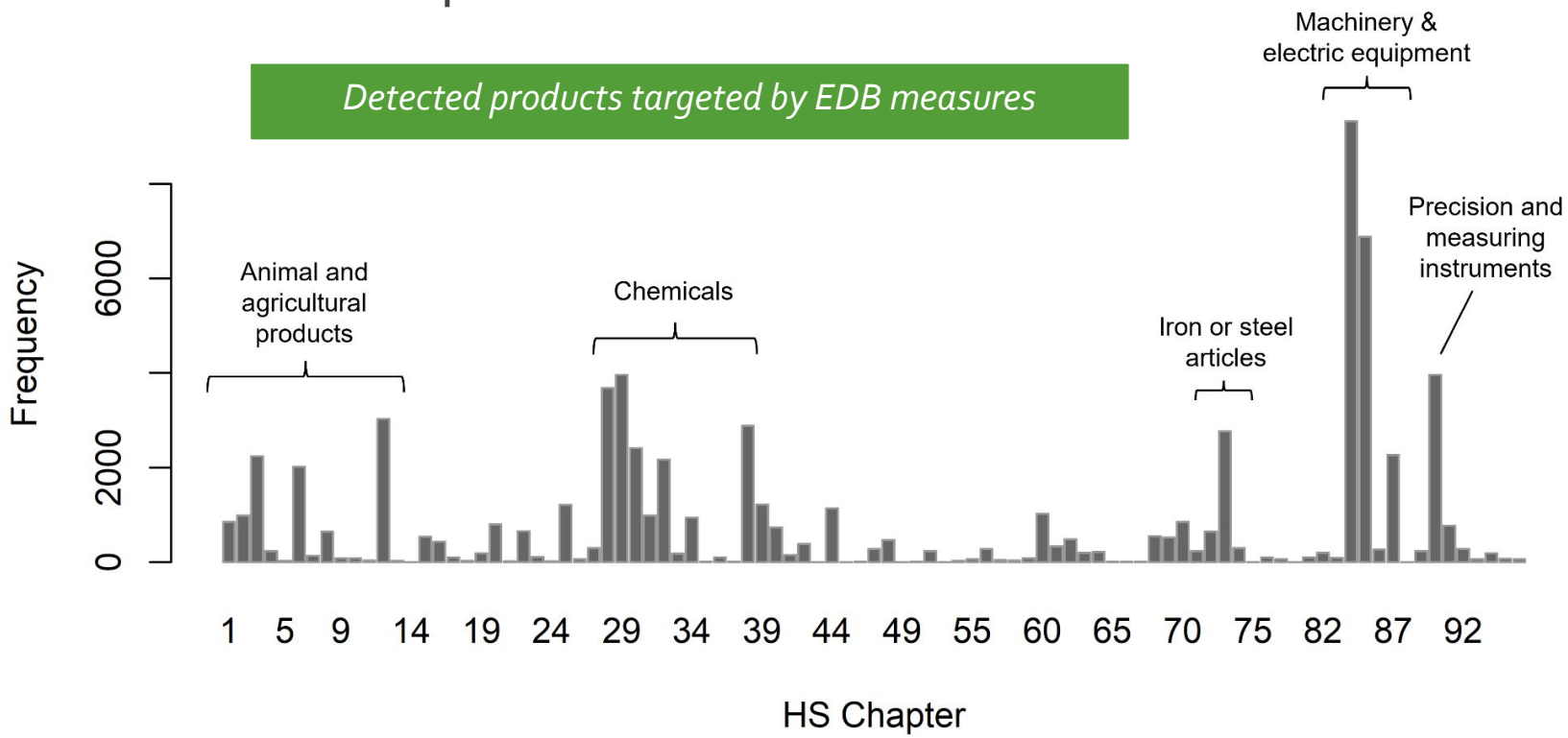


Extending the EDB for economic research

We make information in the database more accessible for economic research by:

a. Extracting the **implementation years** of policy measures

b. Identifying products affected by the policy measures and link them to **HS chapters**.



Extending the EDB for economic research

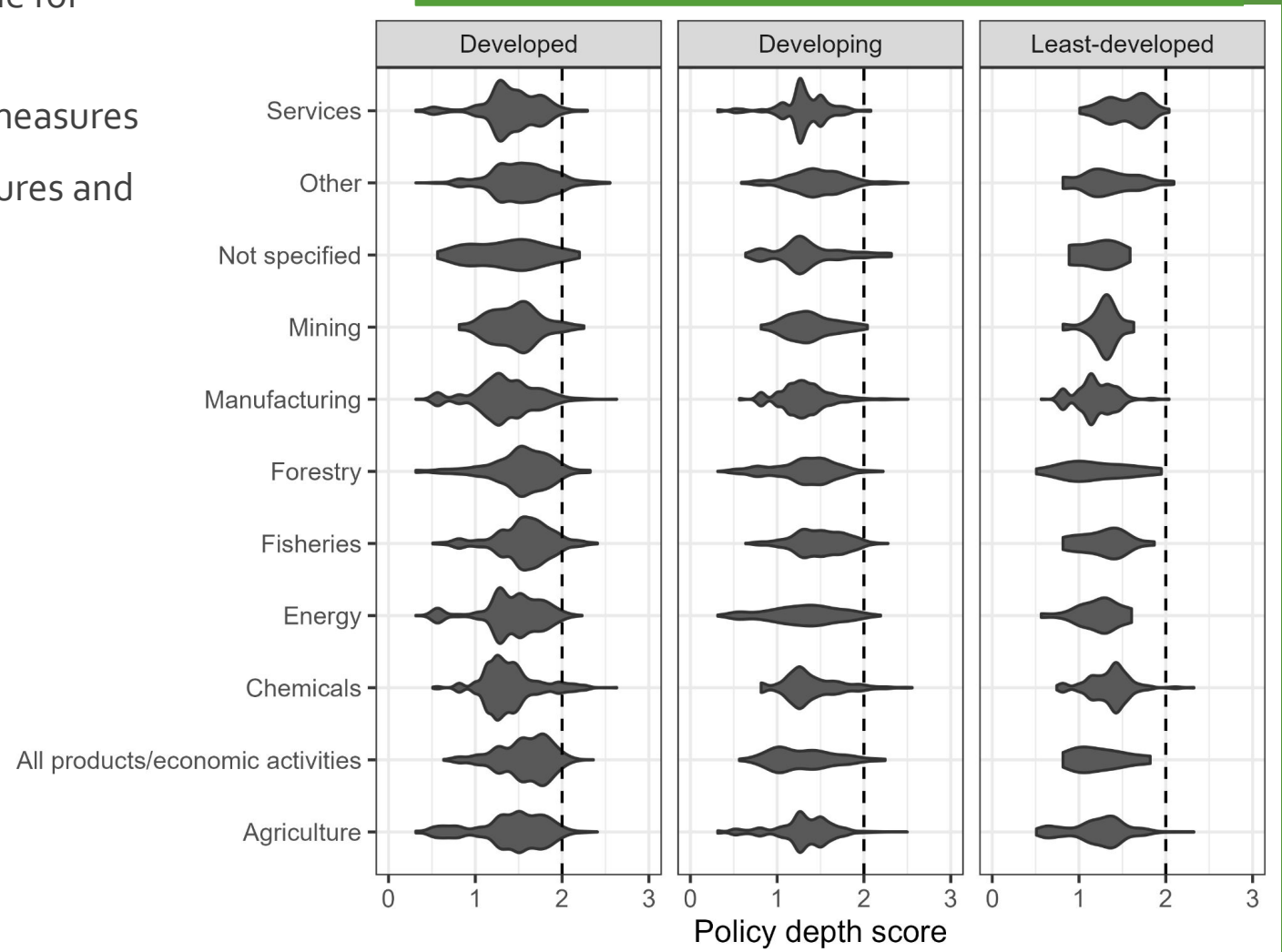
We make information in the database more accessible for economic research by:

a. Extracting the **implementation years** of policy measures

b. Identifying products affected by the policy measures and link them to **HS chapters**.

c. Scoring **policy stringency**

Distribution of policy depth score by development status and sector

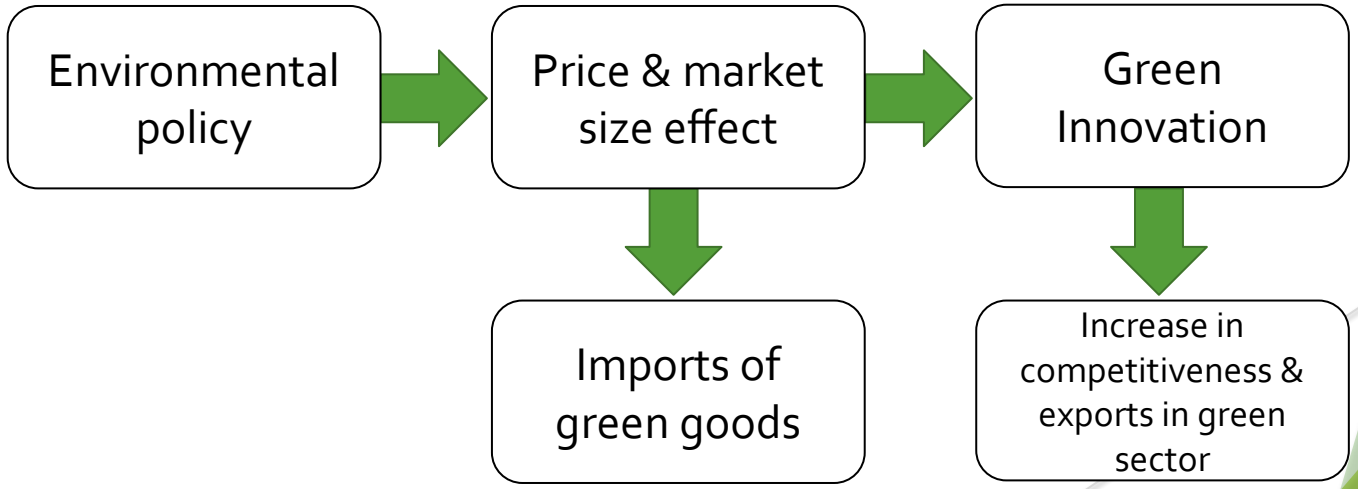


1) Introduction
2) EDB dataset
3) Research question
4) Empirical strategy
5) Results

Research question

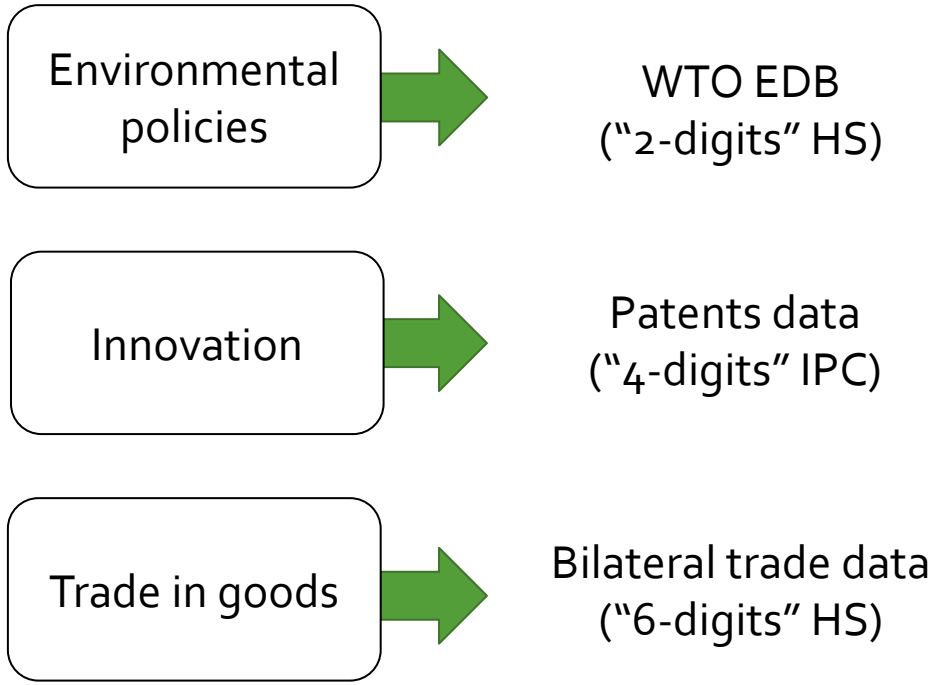
Can environmental policy spur green innovation and trade?

- According to recent literature on directed technical change (e.g. Acemoglu et al., 2012, 2014), environmental policy can be used to direct the economy onto a green growth path. A key role is played by green innovation.
- Empirical literature: pollution haven hypothesis, Porter hypothesis, green innovation literature (e.g. Calel & Dechezleprêtre, 2016; Koźluk & Timiliotis, 2016)
- Leveraging the EDB dataset, we evaluate how different types of environment-related measures have impacted green innovation and trade.



1) Introduction
2) EDB dataset
3) Research question
4) Empirical strategy
5) Results

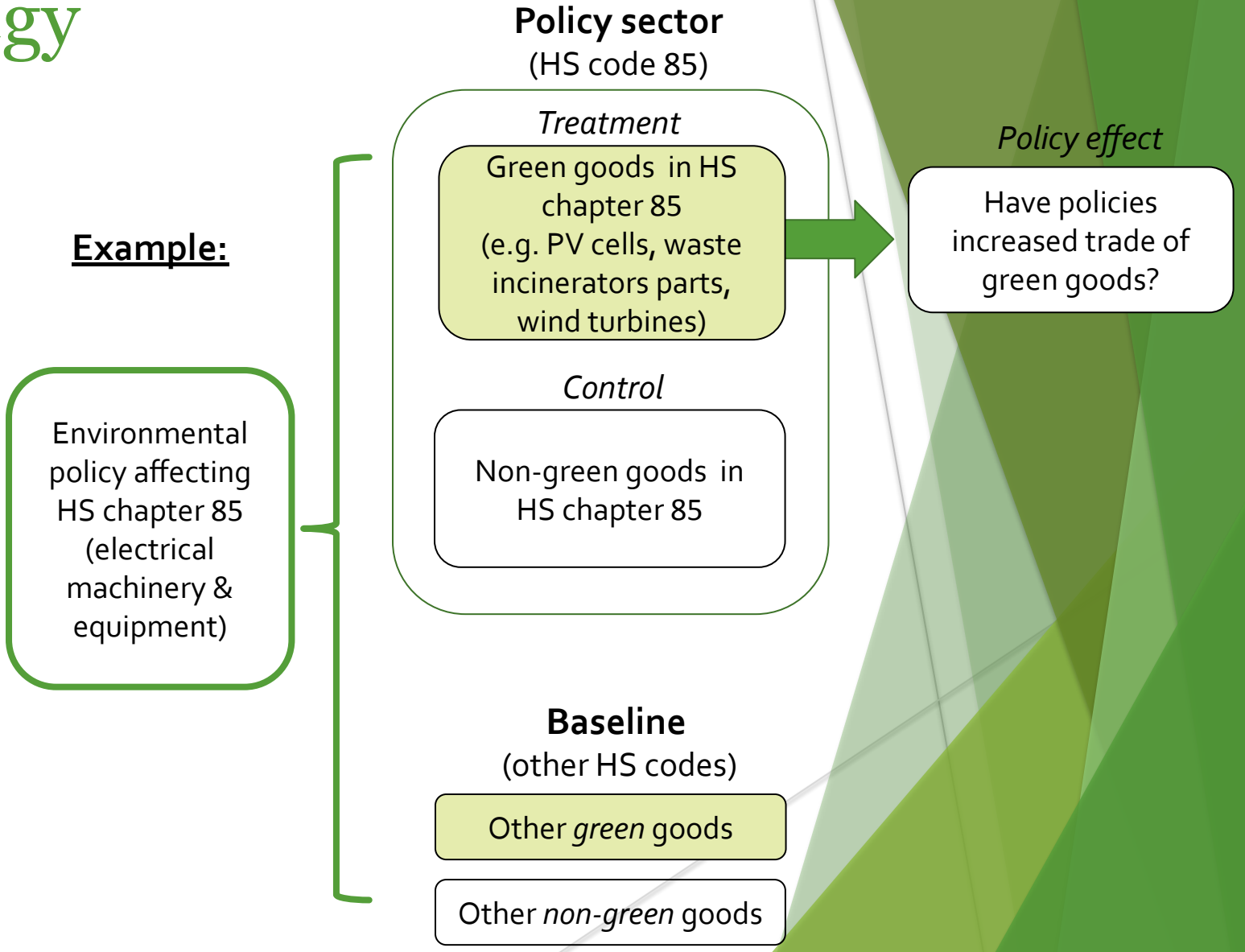
Main variables



Identification strategy

- **Our strategy:** comparing variation in patenting in *green technologies* / trade in *green goods* following environmental policies with *non-green technologies/goods*
- In defining green goods and technologies, we rely on the OECD **CLEG** and **ENV-TECH** lists (Sauvage, 2014; Haščič & Migotto, 2015)
- HS-IPC conversion table (Lybbert & Zolas, 2014)

Example:



Empirical models

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

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

$_i$ = exporter

$_j$ = importer

$_k$ = sector (HS/IPC)

$_t$ = time

D = Dummy green product/tech.

$\bar{M}$ = Pre-sample imports

$\bar{X}$ = Pre-sample exports

u = Error term

K = Knowledge stock

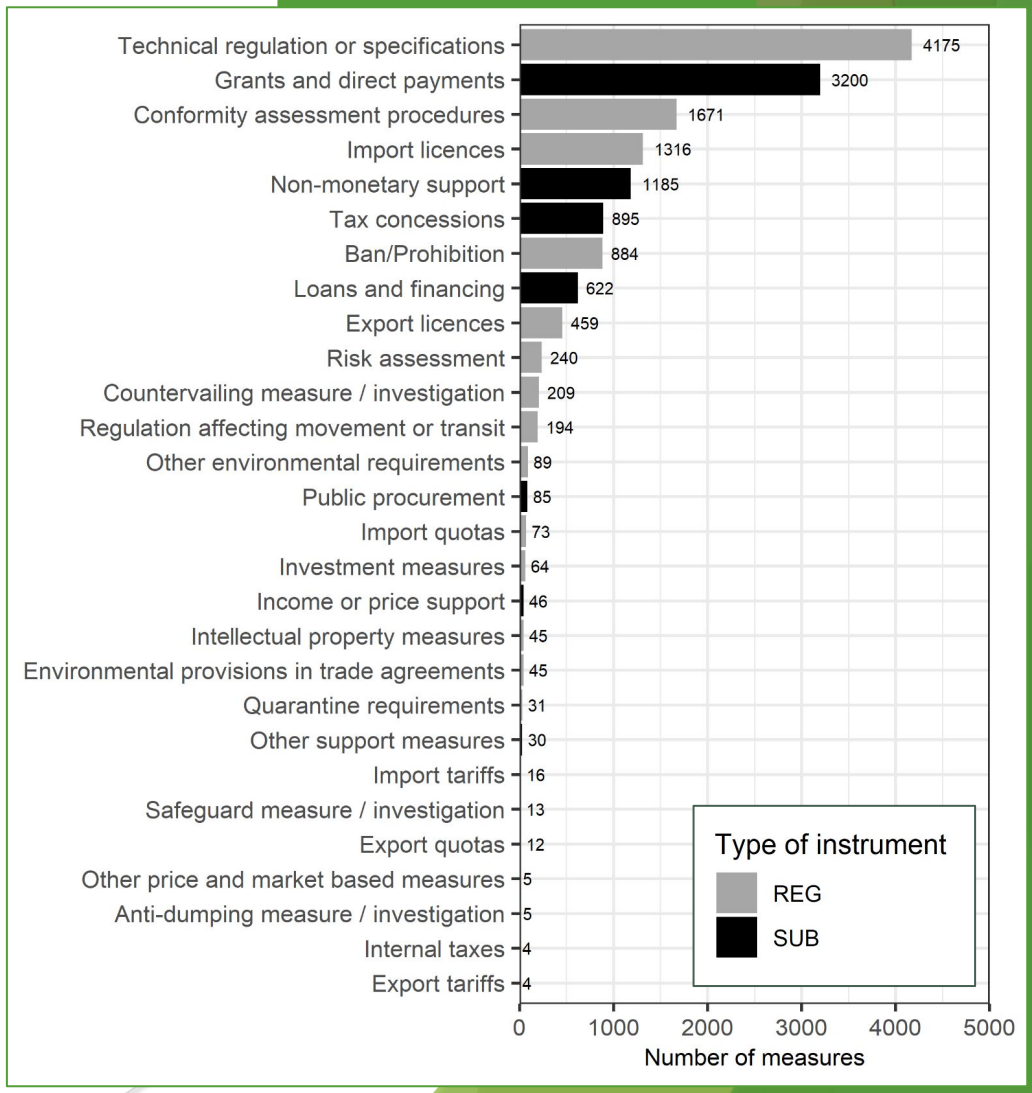
EK = Environmental knowledge stock

RTA = Dummy if any RTA

Empirical models — *Policy variable*

- The policy measures are split in groups according to their policy instruments: 1) Subsidies and support measures [SUB], 2) Regulation, taxes and standards [REG]
- Lagged values of the policy variables are used to mitigate risks of simultaneity
- We experiment with different policy aggregation methods: dummy, count, score
- Rolling averages with different window size is used to disentangle the long run / short run effects of policies

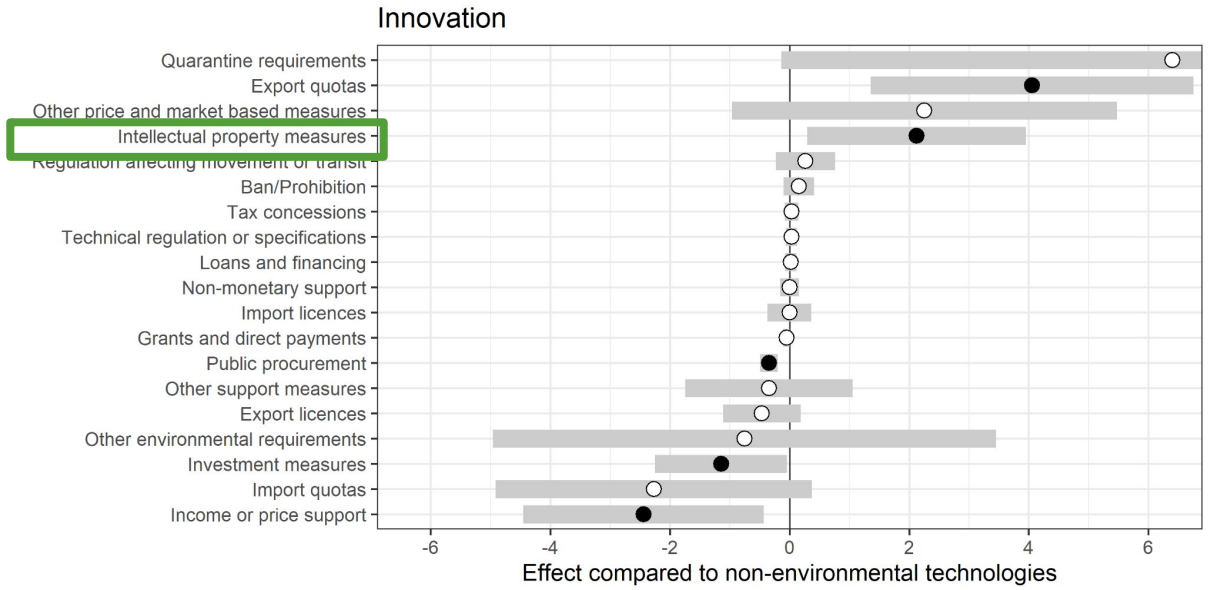
Type of policy instrument



1) Introduction
2) EDB dataset
3) Research question
4) Empirical strategy
5) Results

Main findings on innovation

- Globally, environmental measures are not associated with an increases in environmental innovation. However, **targeted policies**, such as intellectual properties measures and R&D expenditure, do have a positive effect on innovation.
- Accumulated knowledge leads to more innovation. This creates **path dependency** in innovation.
- Countries tend to innovate more in technologies related to their exports and less in technologies they import.

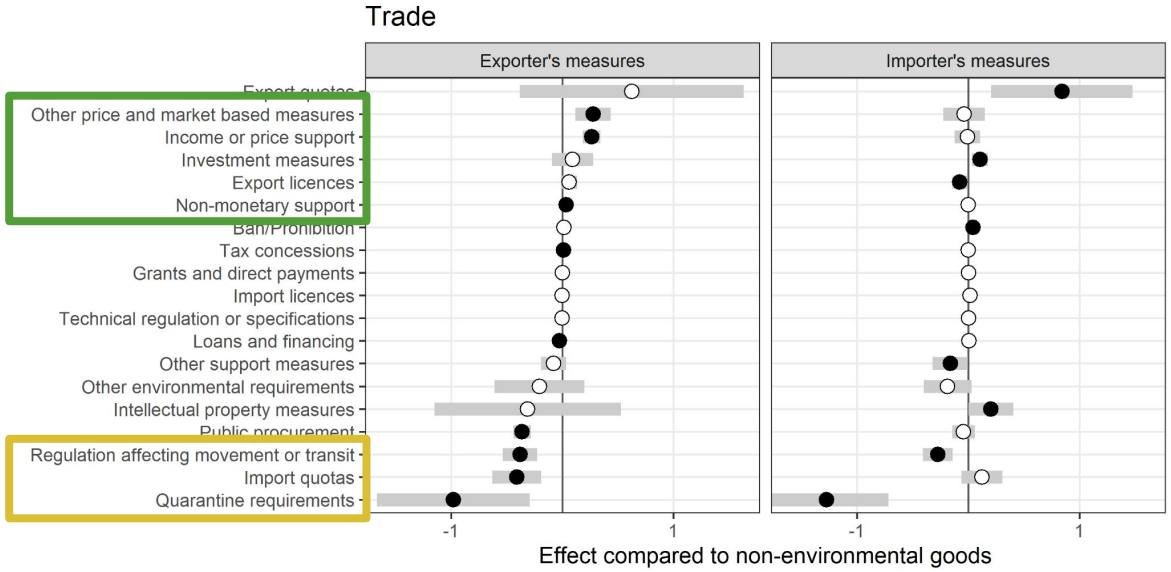


Dependent Variables:	Innovation	
Model:	ST	LT
Policies:		
D × Regulation, tax and standards	-0.001	-0.022
	(0.010)	(0.015)
D × Subsidies and support	0.012	0.005
	(0.018)	(0.021)
Regulation, tax and standards	-0.006	0.001
	(0.007)	(0.010)
Subsidies and support	-0.007	-0.004
	(0.008)	(0.010)
Other variables:		
D × Tot stock env. patents	-0.0003	0.009
	(0.006)	(0.007)
Stock patents sector	0.974***	0.989***
	(0.007)	(0.008)
Pre-sample exports	0.038***	0.032***
	(0.007)	(0.008)
Pre-sample imports	-0.020**	-0.022**
	(0.008)	(0.010)
Fixed-effects		
Country-Year	Yes	Yes
IPC	Yes	Yes
Observations	176,401	109,727
Squared Correlation	0.975	0.977
Pseudo R^2	0.931	0.931
BIC	170,669.6	118,618.2

Notes: ST and LT models indicate short-term (1 year) and longer-term (3 year) policy effects. White-corrected standard-errors presented in parentheses. Significance levels of 0.01, 0.05 and 0.1 indicated respectively by ***, ** and *. All models are estimated with a Poisson pseudo-ML estimator. All explanatory variables are in logarithmic form.

Main findings on trade

- **Subsidies** have a positive effect on exports of environmental goods; whereas on the importer side, they are associated with higher imports of non-environmental goods.
- **Trade restrictive measures** (e.g. quarantine requirements, regulations affecting movement or transit) significantly reduce trade in environmental goods
- Patenting is associated with an increase in trade of related products. In addition, **green innovation leads to growth in the exports of other environmental goods** (e.g. innovation in solar panels may boost exports of batteries too)



Dependent Variables:	Trade			
Model:	ST		LT	
	Exporter	Importer	Exporter	Importer
Policies:				
D × Regulation, tax and standards	-0.019	0.002	-0.005	-0.001
	(0.014)	(0.014)	(0.018)	(0.002)
D × Subsidies and support	0.073***	-0.041**	0.061***	-0.001
	(0.016)	(0.020)	(0.018)	(0.002)
Regulation, tax and standards	0.171***	-0.068***	0.233***	-0.010***
	(0.013)	(0.012)	(0.016)	(0.002)
Subsidies and support	-0.127***	0.064***	-0.135***	0.007***
	(0.013)	(0.015)	(0.015)	(0.001)
Other variables:				
D × Tot stock env. patents	0.192***	0.016***	0.190***	0.012**
	(0.006)	(0.005)	(0.008)	(0.006)
Stock patents sector	0.583***	0.050***	0.590***	0.053***
	(0.011)	(0.007)	(0.013)	(0.007)
RTA	0.093		0.080	
	(0.066)		(0.099)	
Fixed-effects				
Exporter-Importer	Yes		Yes	
Exporter-Year	Yes		Yes	
Importer-Year	Yes		Yes	
HS	Yes		Yes	
Observations	4,996,420		3,552,890	
Squared Correlation	0.576		0.580	
Pseudo R^2	0.821		0.821	
BIC	1.46×10^{11}		1.13×10^{11}	

Notes: ST and LT models indicate short-term (1 year) and longer-term (3 year) policy effects. White-corrected standard-errors presented in parentheses. Significance levels of 0.01, 0.05 and 0.1 indicated respectively by ***, ** and *. All models are estimated with a Poisson pseudo-ML estimator. All explanatory variables are in logarithmic form, except the dummy RTA.

Policy implications

Can environmental policy spur green innovation and trade?

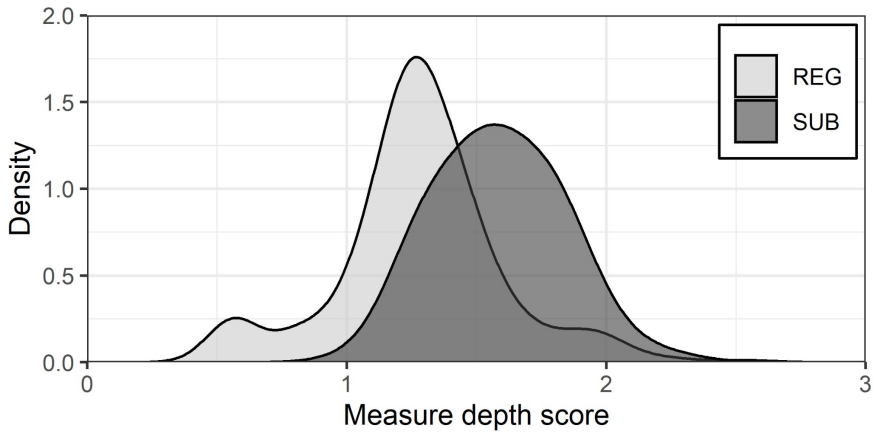
- Environmental policy has a significant effect on green innovation and trade patterns. However, design of the policy matters.
- Green innovation is best stimulated with targeted measures, such as R&D expenditure and measures on intellectual property protection and enforcement.
- Trade in environmental goods appears to be more sensitive to subsidies and other support measures, whereas it is severely hindered by trade restrictive measures.
- The presence of innovation spillovers reduces the cost of government intervention (i.e. there is a *crowding-in* effect).
- Early adoption of environmental measures and R&D support can foster environmental innovation and help transitioning towards a greener economy.
- GVCs and trade should be leveraged as channels of knowledge diffusion and technology adoption.

References

- Acemoglu, D., Aghion, P., Bursztyn, L., & Hémous, 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.
- Calel, R. & Dechezleprêtre, A. (2016). Environmental policy and directed technological change: evidence from the European carbon market. *Review of Economics and Statistics*, 98(1), 173–191.
- 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.
- Koźluk, T. & Timiliotis, C. (2016).Do environmental policies affect global value chains? *OECD Economics Department Working papers*, No. 1282. Available from https://www.oecd-ilibrary.org/content/paper/5jm2hh7nf3wd-en.
- 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.
- WTO Environmental Database: **https://edb.wto.org**

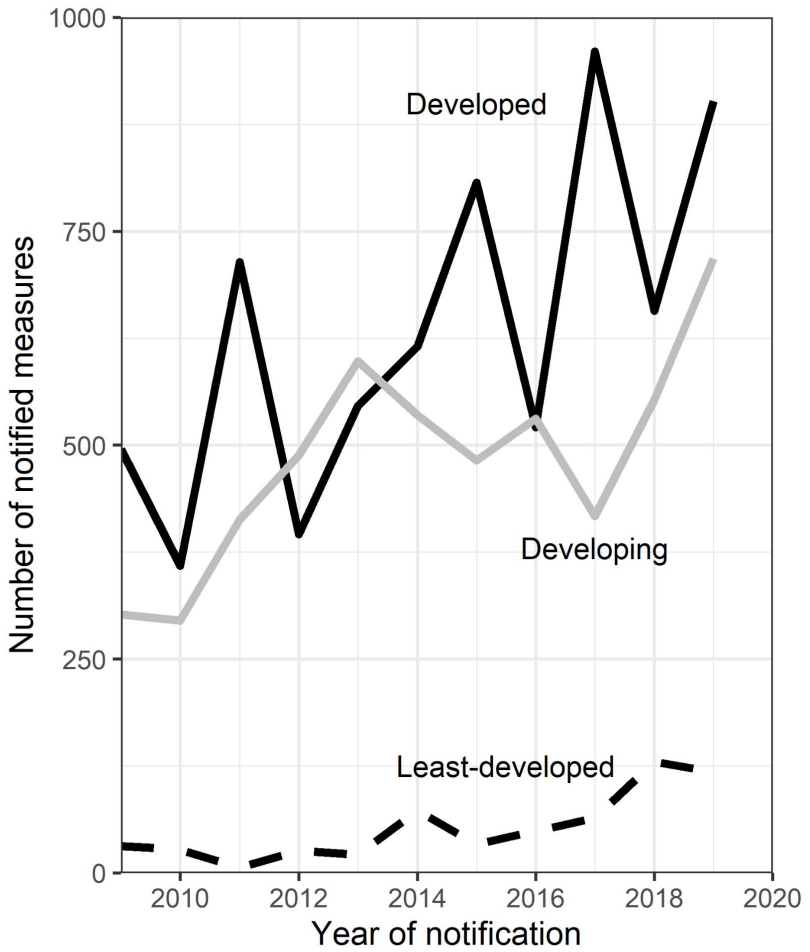
Thank you!

Policy score distribution by type of measure



Final regression country sample

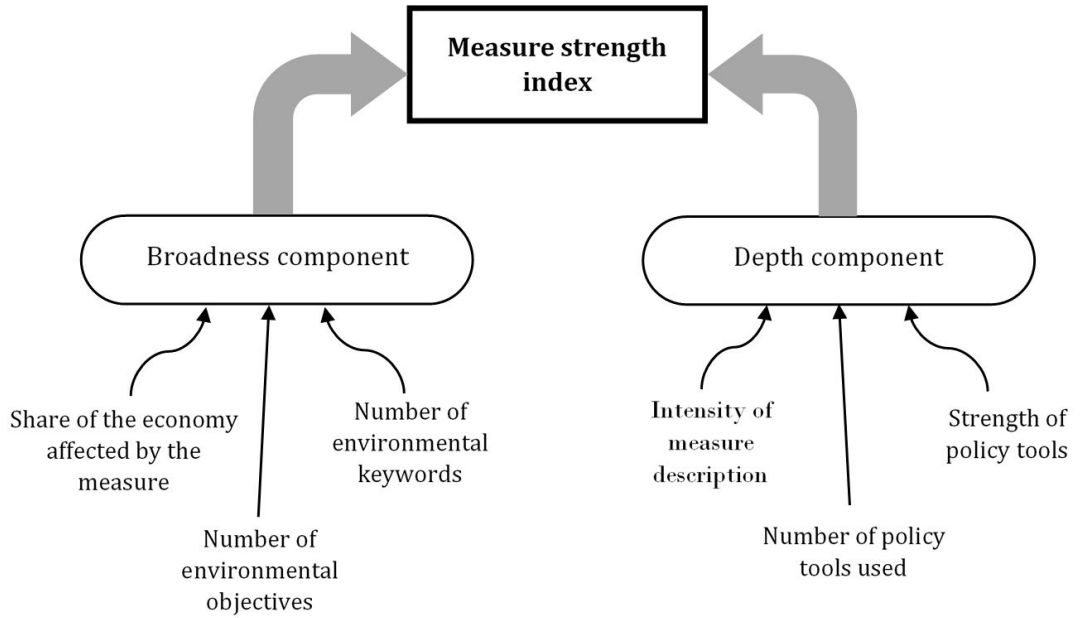
EDB Notified measures by development status



Model:	GVC linkage				R&D subsidies	
	ST	LT	ST	LT	ST	LT
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 industry					0.343***	0.346***
					(0.024)	(0.029)
Policies						
D × 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)
D × 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)
Other variables						
D × 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)
Fixed-effects						
Country-Year	Yes	Yes	Yes	Yes	Yes	Yes
IPC	Yes	Yes	Yes	Yes	Yes	Yes
Observations	6,368	6,368	6,368	6,368	3,836	2,840
Squared Correlation	0.971	0.969	0.974	0.972	0.981	0.979
Pseudo R^2	0.976	0.975	0.976	0.976	0.975	0.974
BIC	50,147.7	50,958.5	48,556.3	49,153.9	41,482.5	30,939.6

Notes: ST and LT models indicate short-term (1 year) and longer-term (3 year) policy effects. Unlike baseline specifications, IPC groups here refer to **1-digit** IPC codes subdivided into environmental and non-environmental technologies. White-corrected standard-errors clustered on Country-Year dyads presented in parentheses. Significance levels of 0.01, 0.05 and 0.1 indicated respectively by ***, ** and *. All models are estimated with a PPML estimator. All independent variables are in logarithmic form.

Components of the policy score



> Click to go back to innovation