Green Innovation and Green Imports

Links between Environmental Policies, Innovation, and Trade

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Camp Resources
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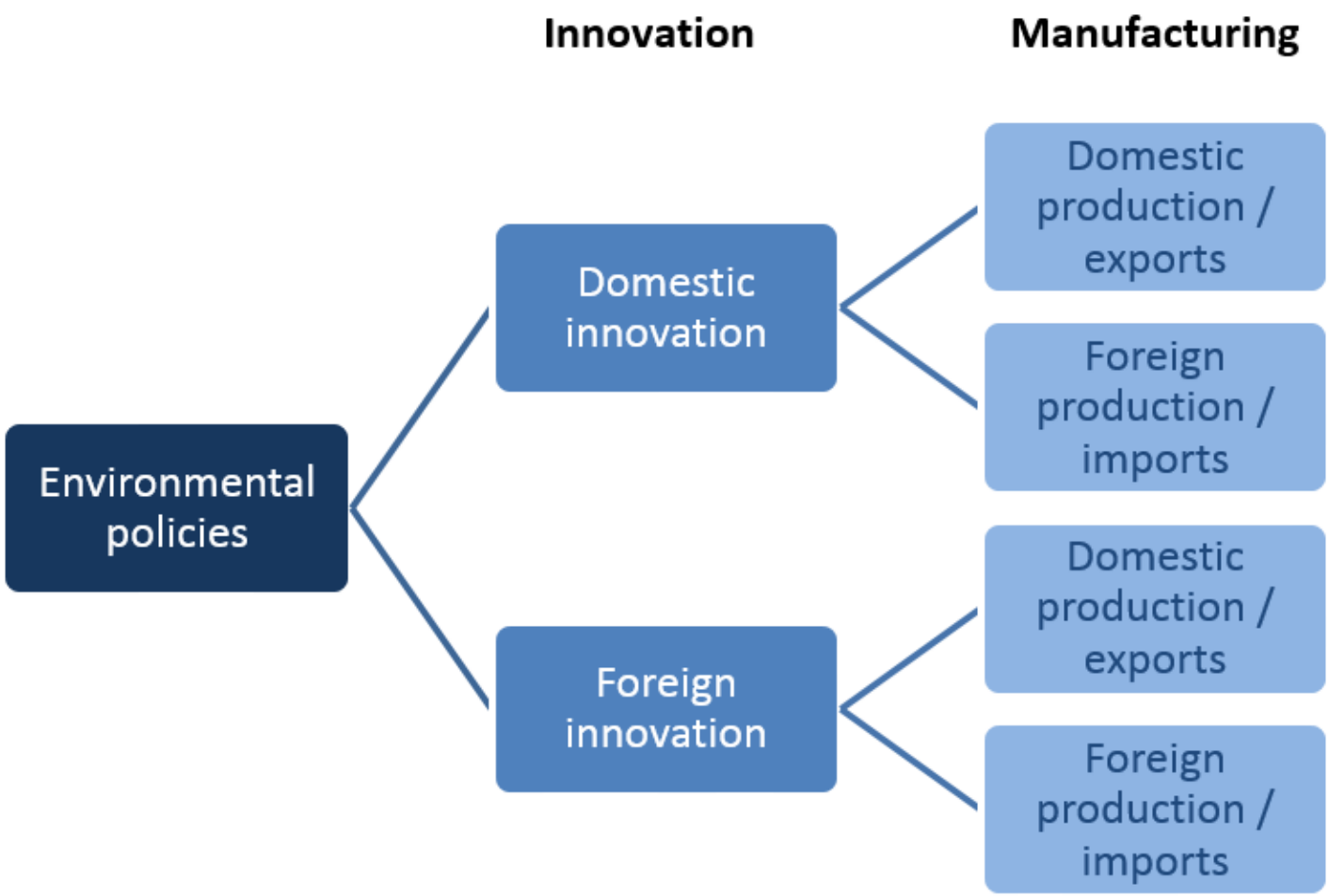
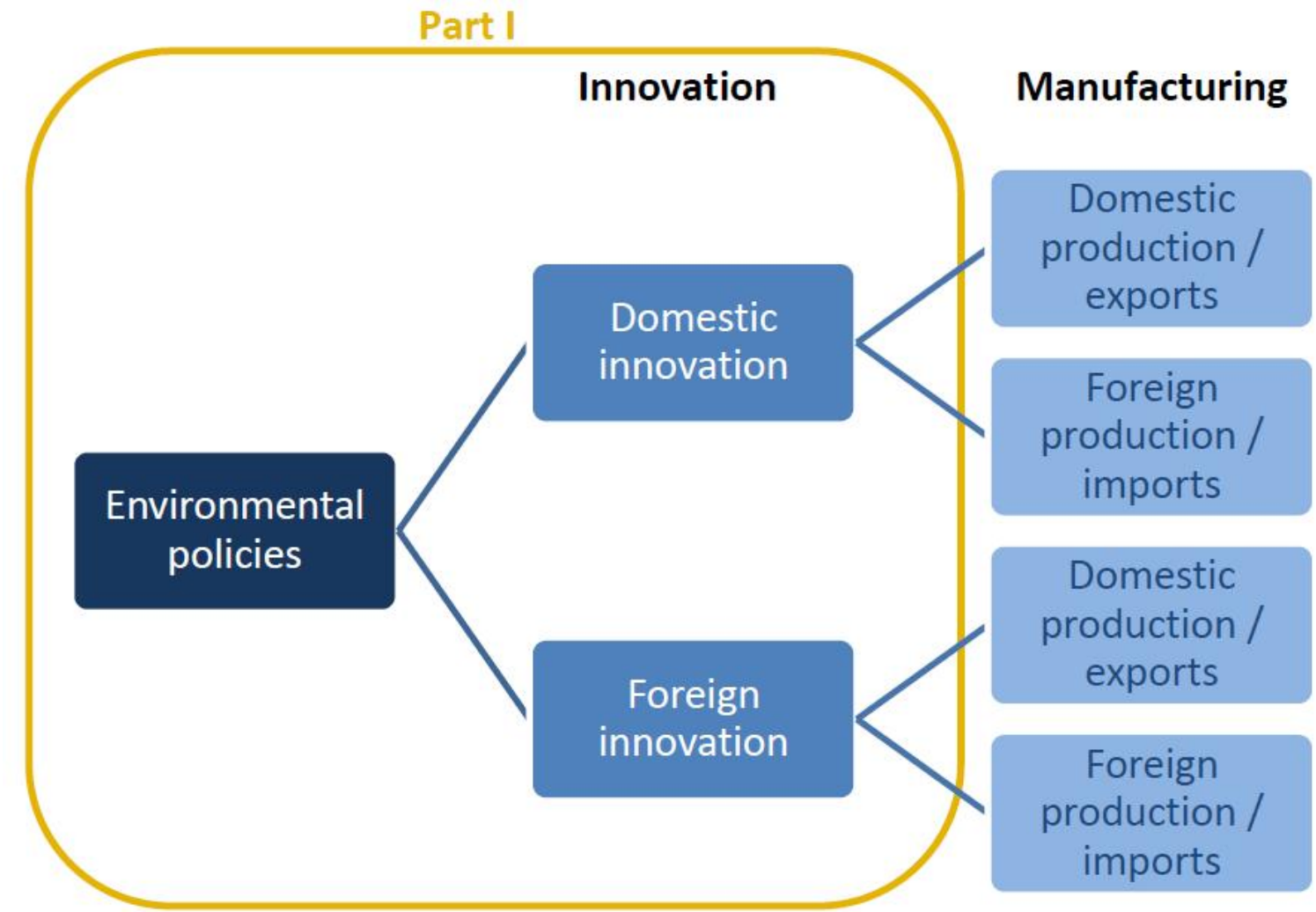
Motivation

- Porter (1991): Environmental policies are a "win-win": they protect the environment and stimulate economic activity.
- The EU's budget proposals for 2014-2020 states: "Climate action objectives will represent at least 20% of EU spending (...) and will enhance Europe's competitiveness."
- President Obama: "I expect those new energy sources to be built right here in the United States." (Presidential Debate, Hempstead, NY, 10/16/12)

Mechanics


Innovation
Manufacturing
Environmental policies
Domestic innovation
Foreign innovation
Domestic production / exports
Foreign production / imports
Domestic production / exports
Foreign production / imports

Mechanics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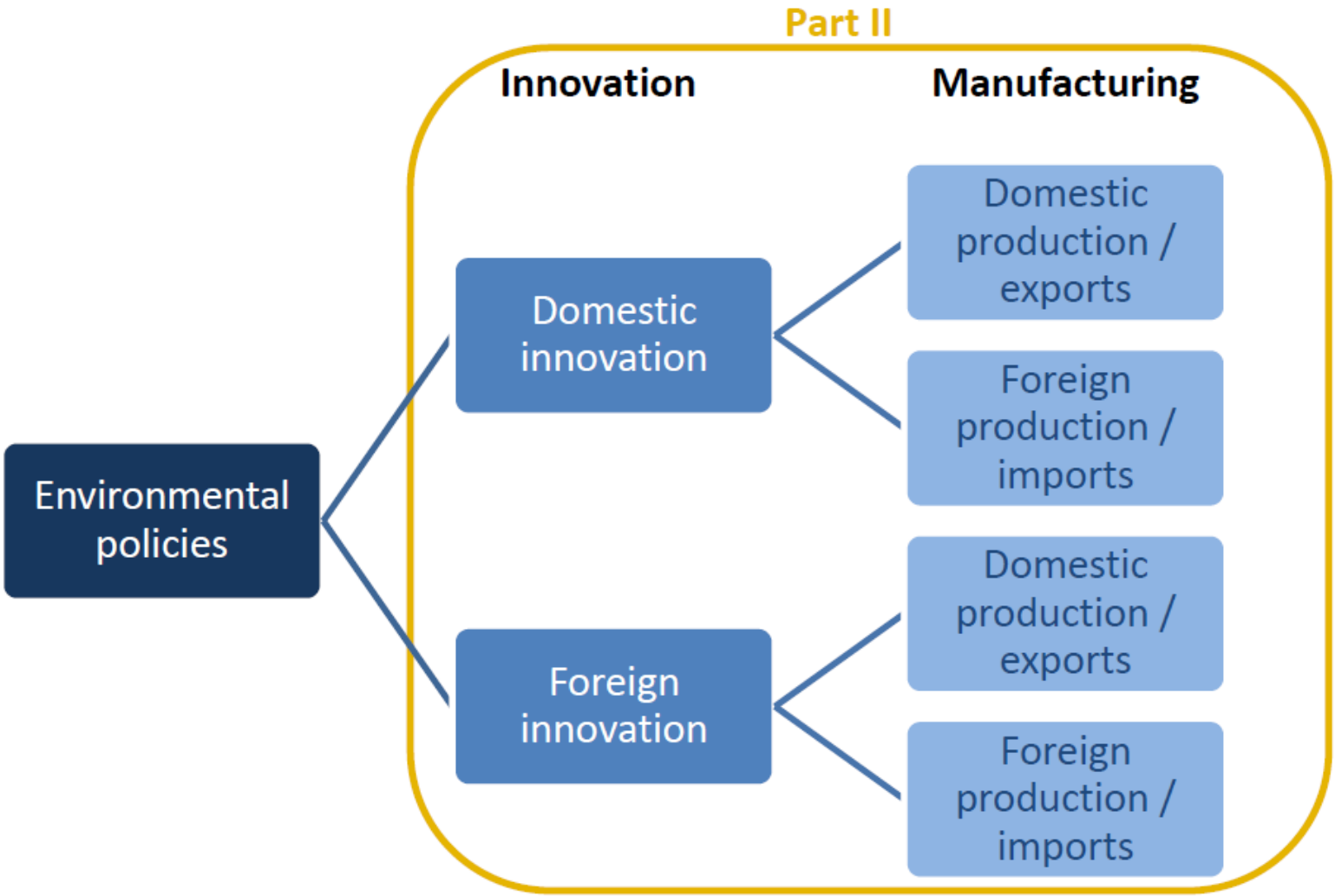
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Research Questions

- Part I: Do environmental policies boost innovation at home and/or abroad?
- Part II: How does innovation induced by environmental policies affect the patterns of trade?

- Study of the renewable energy sector in OECD countries between 1988 and 2003.
  - Solar PV, wind, bioenergy, and geothermal

Part I

Does environmental regulation boost innovation?
Is that innovation developed at home or abroad?

Part I: Environmental Regulation and Innovation: A Review of the Literature

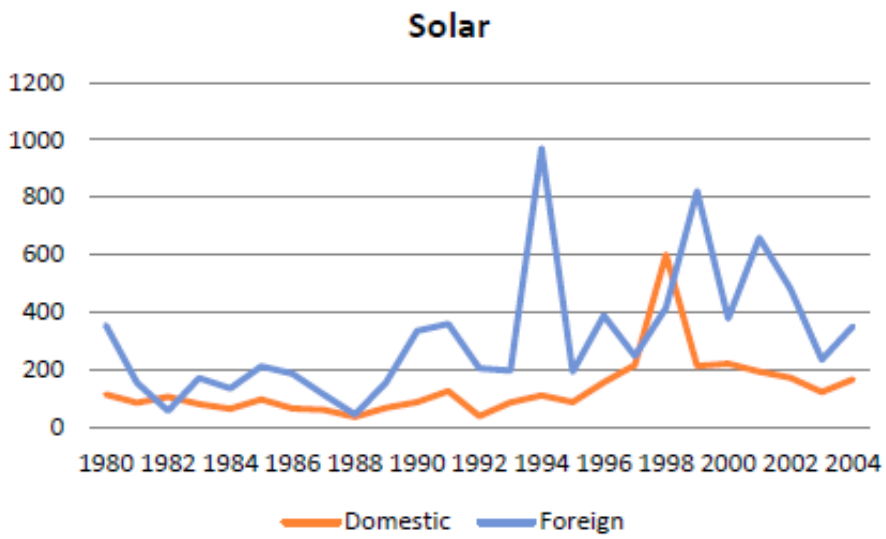
- Environmental policies have a positive effect on innovation:
  - Johnstone, Hascic and Popp (2010), Jaffe and Palmer (1997).
- But is this result driven by foreign or domestic innovation?
  - Spillovers of regulation on transfer of foreign innovation: Dechezleprêtre and Glachant (2012), Peters, Schneider, Griesshaber and Hoffmann (2012).

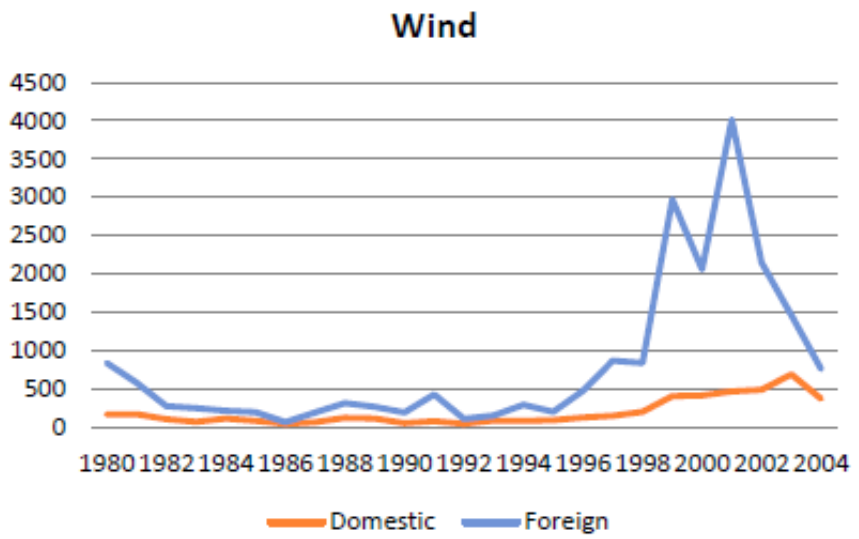
Measure of Innovation

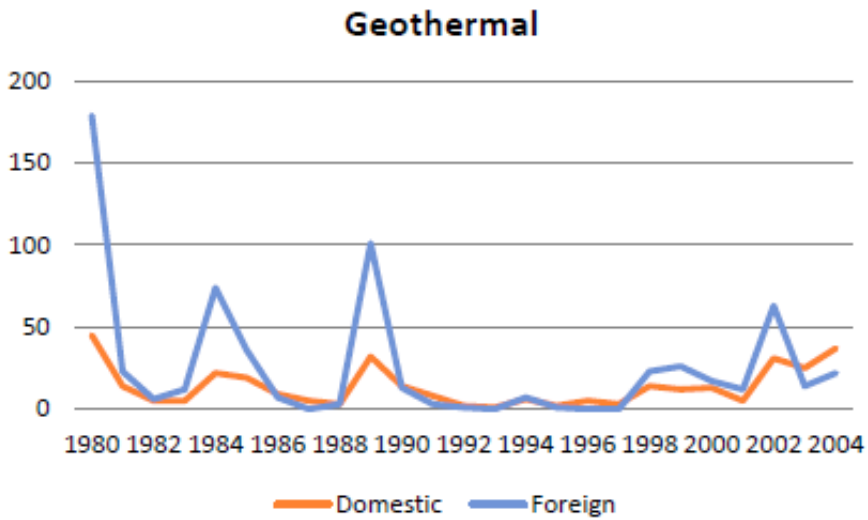
- PATSTAT dataset of the European Patent Office (EPO):
  - 60 million patents covering about 200 countries.
  - Date of application, publication, country of filing, country of the inventor, and family size.
  - International Patent Classification. IPC codes
  - Collected additional data on Member State designation for EU patents.
  - Weighted by family size.

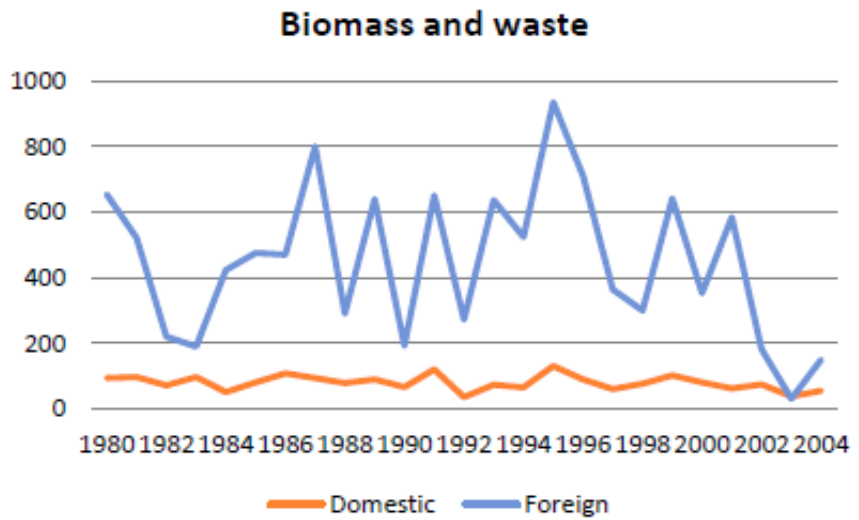
- Domestic versus foreign innovation determined by the country of the inventor.

Renewable Patents in the EU, by Technology









Measure of Policy Stringency

- Policies: research and development incentives, investment incentives, tax incentives, feed-in tariffs, obligations, tradable certificates.
- Data: IEA/IRENA Joint Policies and Measures database of policy measures for renewable energy in over 100 countries.
- Measure: count of policies.

Summary Statistics for Policy Stringency

Table : Summary statistics

Variable	Mean	Std. Dev.	Min.	Max.
Pol. stringency	0.673	1.609	0	10
R&D	0.038	0.212	0	2
Policy support	0.121	0.344	0	2
Information and education	0.073	0.289	0	2
Regulatory instruments	0.117	0.369	0	2
Economic instruments	0.268	0.690	0	6
Voluntary contributions	0.056	0.24	0	2

Estimation Equations

$$DomesticPat_{it} = \beta_1^H POL_{it} + \beta_2^H X_{it} + \delta_t^H + \epsilon_{it}^H$$

$$ForeignPat_{it} = \beta_1^F POL_{it} + \beta_2^F X_{it} + \delta_t^F + \epsilon_{it}^F$$

- X_{it} includes:
  - World policy stringency.
  - Electricity prices.
  - Electricity consumption.
  - The stock of existing renewable patents in country i at time t-1.
  - A country-specific patenting trend.
- Estimate using negative binomial.

Regression Results - All policies

	(1) All patents	(2) Domestic patents	(3) Foreign patents
Pol. stringency	1.059**	1.067**	1.054*
	(0.021)	(0.025)	(0.022)
World stringency	1.003	0.990	1.002
	(0.005)	(0.006)	(0.005)
Elec. consumption	1.001***	0.999***	1.001***
	(0.000)	(0.000)	(0.000)
Elec. price	0.997***	0.997***	0.997***
	(0.001)	(0.001)	(0.001)
Stock(t-1)	1.114***	1.137***	1.121***
	(0.009)	(0.010)	(0.010)
Patenting trend	0.992***	1.012***	0.988***
	(0.002)	(0.002)	(0.002)

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Robust standard errors in parentheses; N=418

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Regression Results - Policies lagged

	(1) All patents	(2) Domestic patents	(3) Foreign patents
Policy(t-1)	1.047*	1.054*	1.039
	(0.021)	(0.026)	(0.022)
World policy(t-1)	0.999	0.980**	0.998
	(0.005)	(0.007)	(0.005)
Elec. cons.	1.001***	0.999***	1.001***
	(0.000)	(0.000)	(0.000)
Elec. price	0.998**	0.997***	0.998**
	(0.001)	(0.001)	(0.001)
Stock(t-1)	1.115***	1.146***	1.122***
	(0.010)	(0.011)	(0.010)
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Regression Results - Economic Instruments Only

	(1) All patents	(2) Domestic patents	(3) Foreign patents
Economic instruments	1.132**	1.156**	1.121*
	(0.052)	(0.062)	(0.054)
Econ. inst. world	1.002	0.983	1.000
	(0.009)	(0.010)	(0.009)
Elec. cons.	1.001***	0.999***	1.001***
	(0.000)	(0.000)	(0.000)
Elec. price	0.998**	0.997***	0.998**
	(0.001)	(0.001)	(0.001)
Stock(t-1)	1.000***	1.000***	1.000***
	(0.000)	(0.000)	(0.000)
Patenting trend	0.993***	1.012***	0.989***
	(0.002)	(0.002)	(0.002)

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Robust standard errors in parentheses; N=418

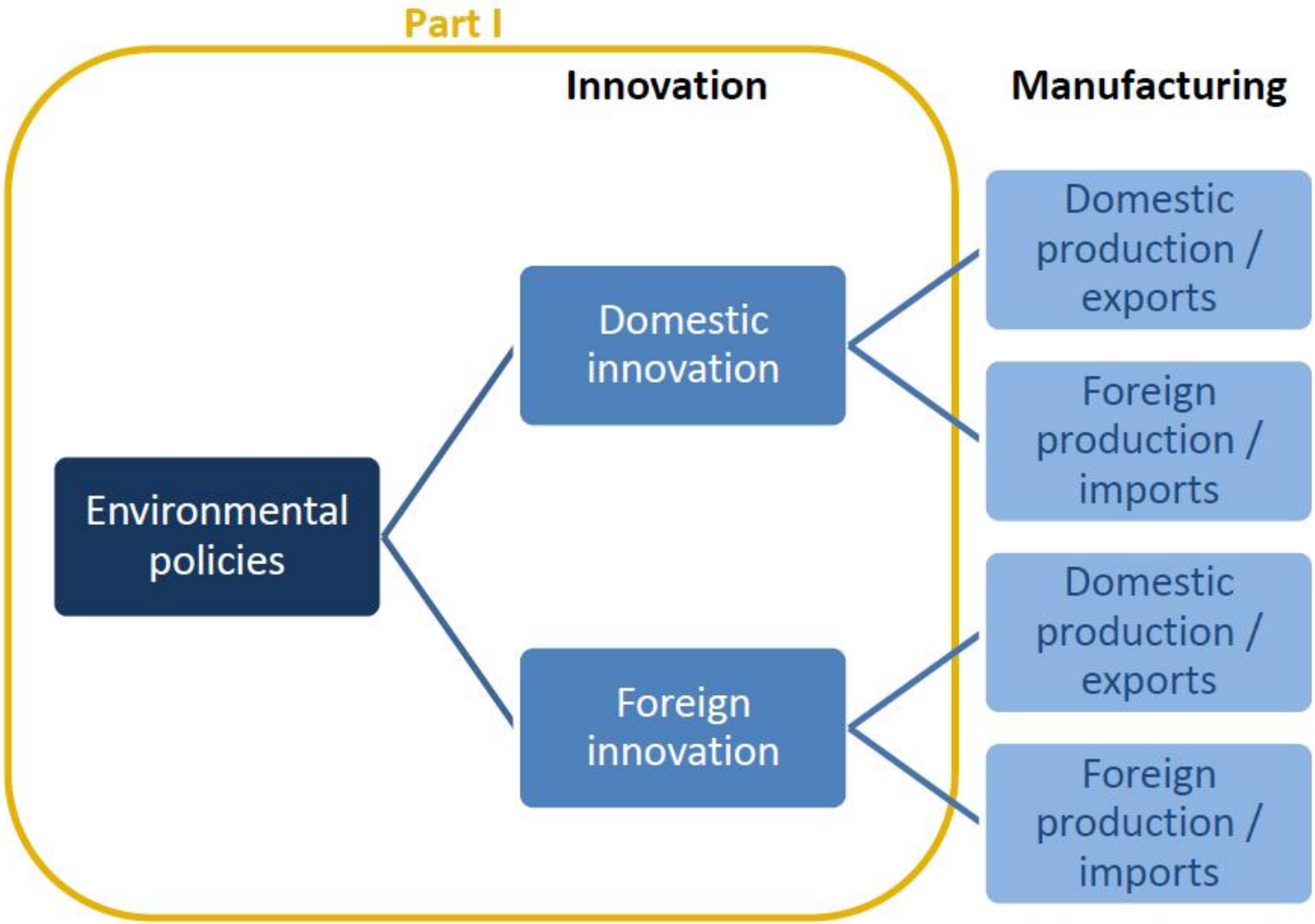
Regression Results - Solar Only

	(1) All patents	(2) Domestic patents	(3) Foreign patents
Pol. stringency	1.075^{+}	1.040	1.077^{+}
	(0.045)	(0.056)	(0.046)
World stringency	0.996	0.993	0.996
	(0.006)	(0.010)	(0.006)
Elec. cons.	1.000	0.999*	1.000
	(0.000)	(0.000)	(0.000)
Elec. price	0.992*	0.994*	0.992*
	(0.001)	(0.002)	(0.001)
Stock(t-1)	1.000*	1.000*	1.000*
	(0.000)	(0.000)	(0.000)
Patenting trend	1.001	1.011*	1.000
	(0.002)	(0.002)	(0.002)

$^{+}$ $p < 0.10$, * $p < 0.05$

Robust standard errors in parentheses; N=418

Recap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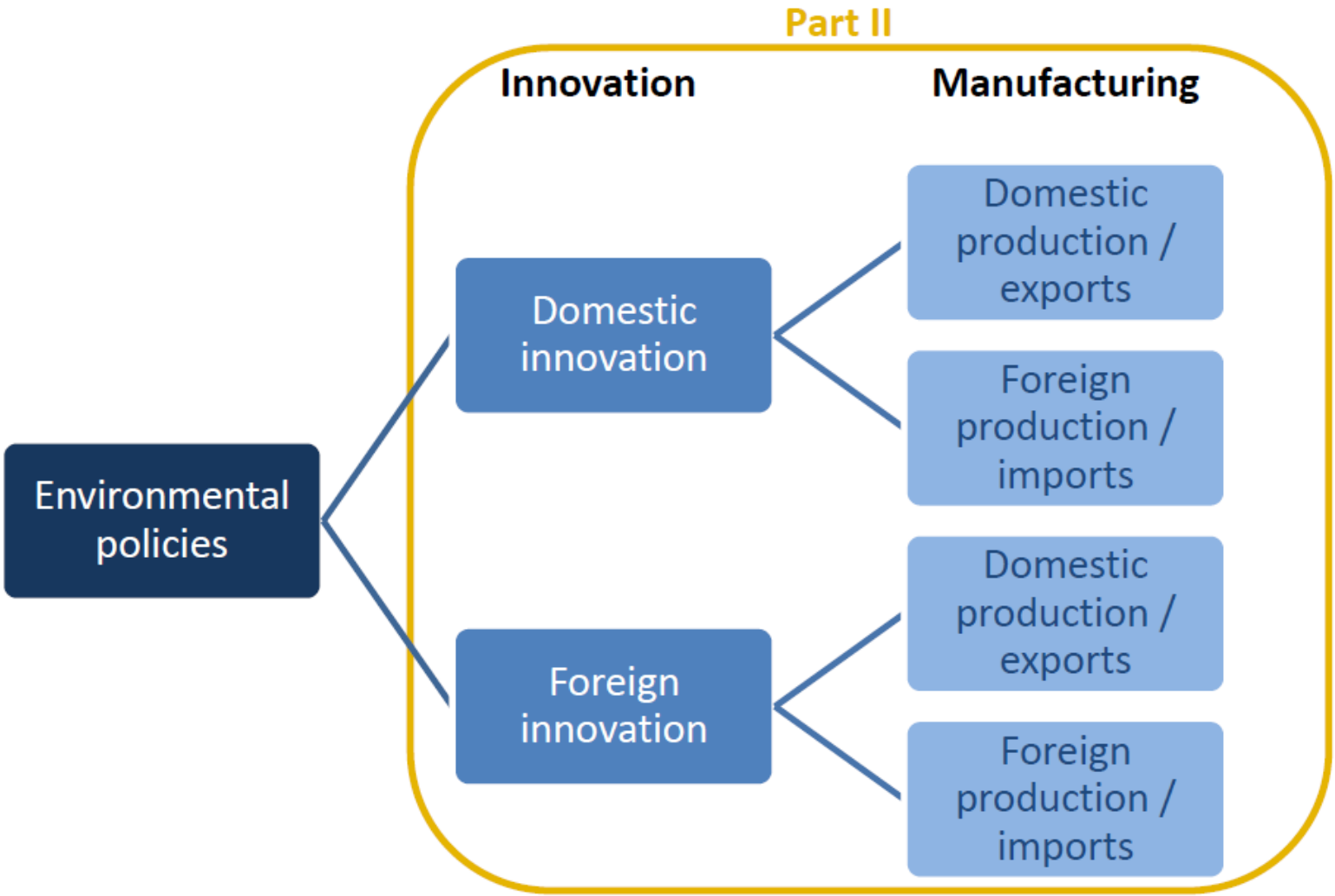
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Part II

Are the technologies, whether domestic or foreign, imported from abroad or manufactured domestically?

Part II: Innovation and Trade: A Review of the Literature

- Most studies look at how trade can drive innovation:
  - Keller (2004), Bloom, Draka and Reener (2012), Batrakova and Dechezleprêtre (2013)
- Gap in the literature for how environmental innovation stimulate imports.

Estimation Equation

$$M_{ijt} = \alpha^M + \beta_1^M \widehat{K_{it}} + \beta_2^M X_{ijt} + \gamma_i^M + \delta_j^M + \nu_{ijt}^M$$

$$X_{ijt} = \alpha^X + \beta_1^X \widehat{K_{it}} + \beta_2^X X_{ijt} + \gamma_i^X + \delta_j^X + \nu_{ijt}^X$$

- $\widehat{K_{it}}$ is the stock of patents for renewable energies:

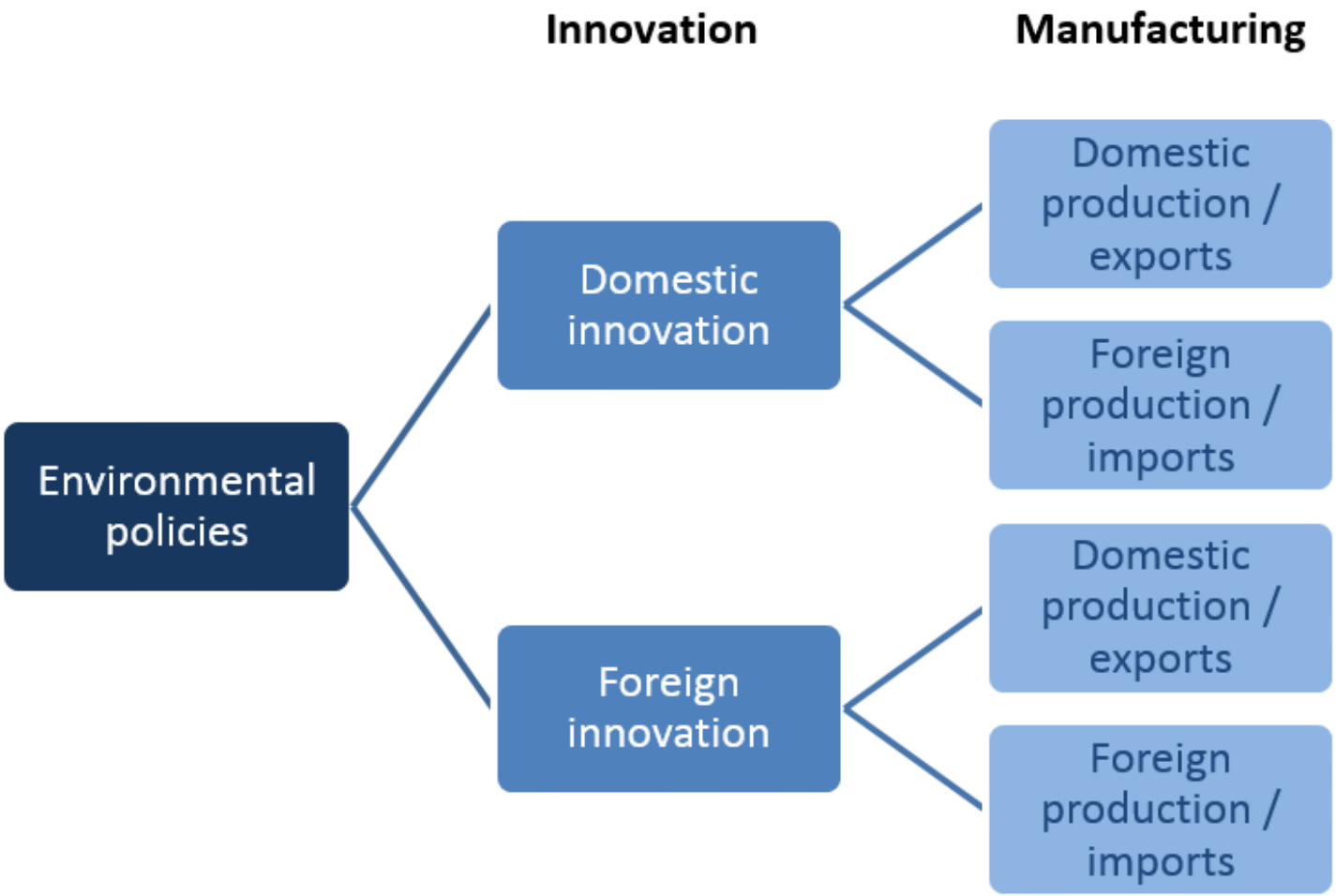
$$\widehat{K_{it}} = \sum_{s=0}^{\infty} e^{-\beta_1 s}(1 - e^{-\beta_2(1+s)}) * \widehat{PAT_{i(t-s)}}$$

Preliminary Results

	(1) ln(imports)	(2) ln(exports)
Renewable patent stock	0.002***	-0.000
	(0.000)	(0.000)
Log GDP p.c. in origin	0.900***	0.636***
	(0.075)	(0.059)
Log GDP p.c. in destination	0.648***	0.992***
	(0.060)	(0.041)
Log distance	-1.237***	-1.646***
	(0.019)	(0.016)
Common border	0.581***	0.161**
	(0.052)	(0.052)
Common language	0.348***	0.718***
	(0.042)	(0.031)
Colonial ties	0.859***	1.860***
	(0.081)	(0.054)

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Conclusion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The End

Table 1. Patent Classes of Renewable Energy Technologies

Patent classification description	IPC code
WIND	
Wind motors	F03D
SOLAR PHOTOVOLTAICS	
Semiconductor devices sensitive to infrared radiation, light, electromagnetic radiation of shorter wavelength, or corpuscular radiation and specially adapted either for the conversion of the energy of such radiation into electrical energy or for the control of electrical energy by such radiation—adapted as conversion devices, including a panel or array of photoelectric cells, e.g., solar cells	H01L 31/04-058
Generators in which light radiation is directly converted into electrical energy	H02N 6/00
Devices consisting of a plurality of semiconductor components sensitive to infrared radiation, light, electromagnetic radiation of shorter wavelength, or corpuscular radiation—specially adapted for the conversion of the energy of such radiation into electrical energy	H01L 27/142
GEOTHERMAL	
Other production or use of heat, not derived from combustion—using natural or geothermal heat	F24J 3/08
Devices for producing mechanical power from geothermal energy	F03G 4/00-06
BIOMASS & WASTE	
Solid fuels essentially based on materials of nonmineral origin–animal or vegetable substances; sewage, town, or house refuse; industrial residues or waste materials	C10L 5/42-48
Engines or plants operating on gaseous fuel generated from solid fuel, e.g., wood	F02B 43/08
Liquid carbonaceous fuels	C10L1
Gaseous fuels	C10L3
Solid fuels	C10L5
Dumping solid waste	B09B1
Destroying solid waste or transforming solid waste into something useful or harmless	B09B3
Incineration of waste; incinerator constructions	F23G5
Incinerators or other apparatus specially adapted for consuming specific waste or low grade fuels, e.g., chemicals	F23G7
Plants or engines characterized by use of industrial or other waste gases	F01K 25/14
Incineration of waste—recuperation of heat	F23G 5/46
Plants for converting heat or fluid energy into mechanical energy; use of waste heat	F01K27
Use of waste heat of combustion engines—Profiting from waste heat of combustion engines	F02G5
Machines, plant, or systems, using particular sources of energy—using waste heat, e.g., from internal-combustion engines	F25B 27/02

Source: Popp (2011), Johnstone et al (2010), WIPO Green Inventory Tool, EPO EGS classification

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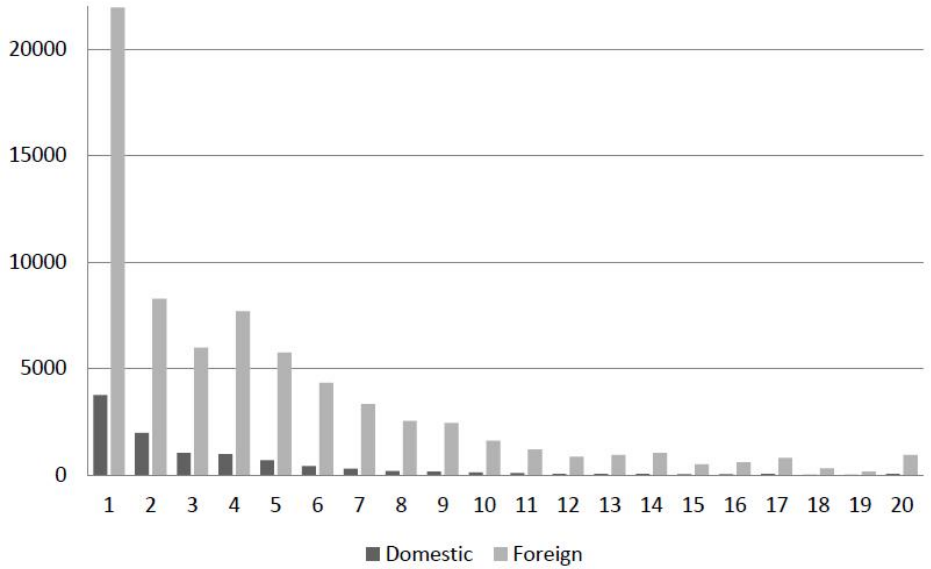
Patent Summary Statistics

Table : Weighted patent counts

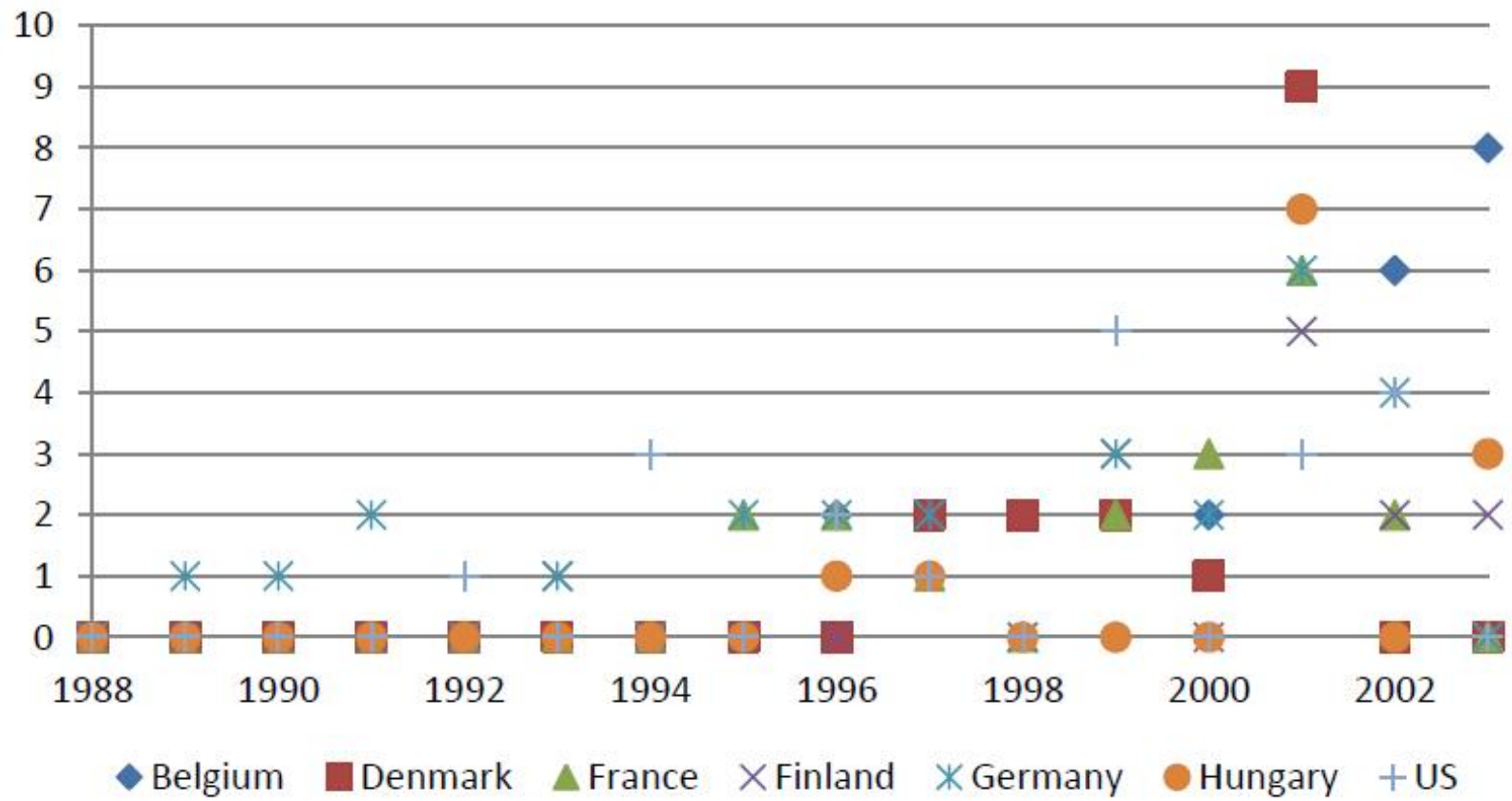
Variable	Mean	Std. Dev.	Min.	Max.
All patents	604	741	0	3851
Domestic patents	54	170	0	2018
Foreign patents	550	665	0	3341

Figure : Frequency plot of family size by origin



Trend of Policy Stringency

Figure : Policy Stringency for Selected Countries



Regression Results - Regulatory Instruments Only

	(1) All patents	(2) Domestic patents	(3) Foreign patents
Regulatory instruments	1.161	1.317**	1.124
	(0.098)	(0.112)	(0.100)
Reg. inst. world	1.008	0.958	1.007
	(0.023)	(0.026)	(0.023)
Elec. cons.	1.001***	0.999***	1.001***
	(0.000)	(0.000)	(0.000)
Elec. price	0.997***	0.997***	0.997***
	(0.001)	(0.001)	(0.001)
stocklag	1.000***	1.000***	1.000***
	(0.000)	(0.000)	(0.000)
Patenting trend	0.992***	1.011***	0.988***
	(0.002)	(0.002)	(0.002)

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