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ENVIRONMENTAL EXPENDITURES AND MANUFACTURING INDUSTRY PERFORMANCE:

EVIDENCE ON PORTER HYPOTHESIS IN TURKISH MANUFACTURING INDUSTRY

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Outline

1. Motivation
2. Theory and Research
3. Literature Review
4. Empirical Analysis
5. Conclusion

Motivation (1)

- Increasing economic activity and the threat of the environmental pollution
- Human induced climate change and mitigation policies

  → Kyoto Protocol, EU2020 targets, COPs, etc.
- COP21 Paris
  - main target:

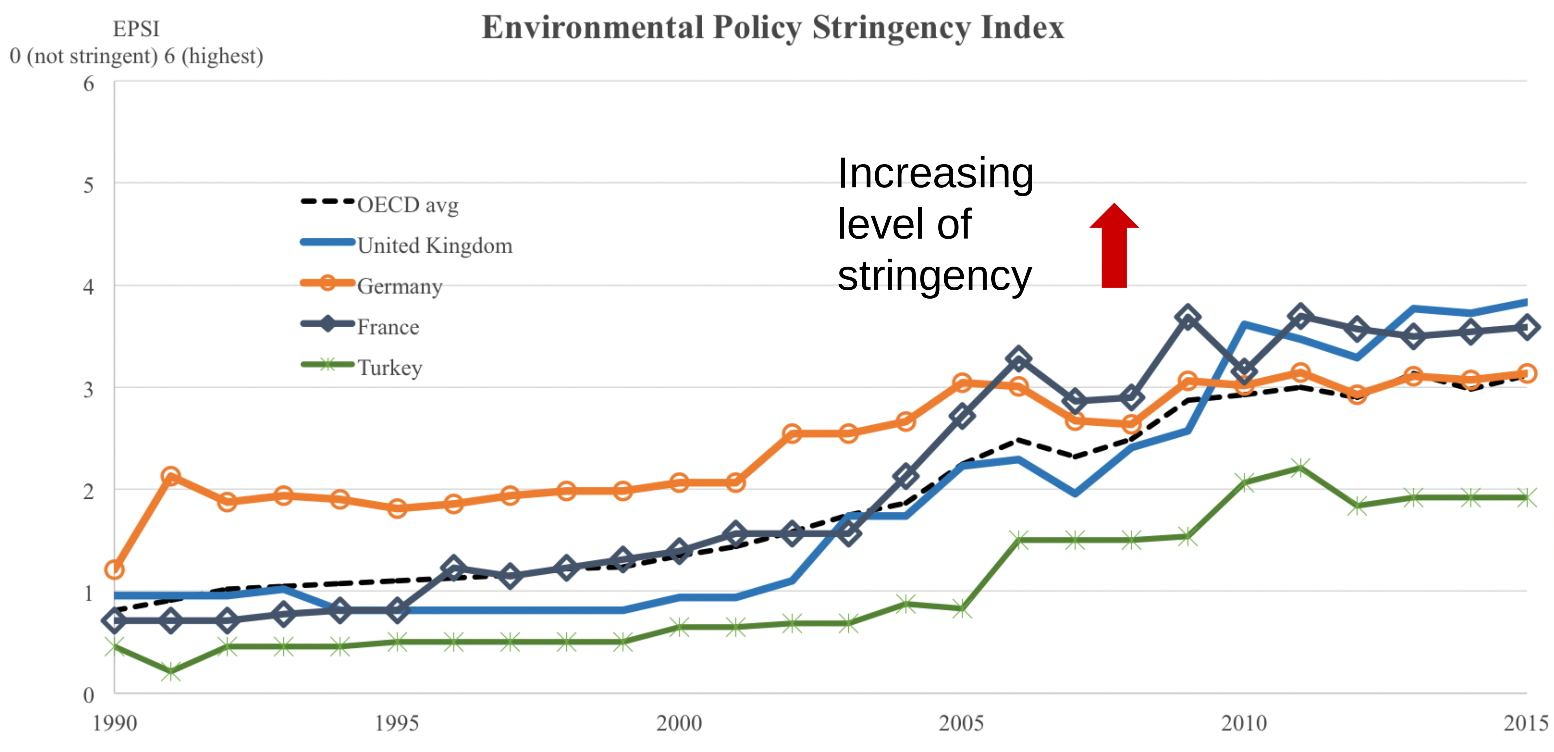
    → 1.5◦C above pre-industrial levels

    → targets of GHG emissions
  - Intended national determined contributions (INDCs):

    Turkey → 21% reduction from BAU expected 1.175 billion tons of CO2 equivalent by 2030.
- Governmental regulations: regulatory pressures on the firms affect the investment decisions of individual firms and industries.
- Environmental expenditures of firms tend to increase.

Motivation (2)

Figure 1: Environmental Policy Stringency Index



Source: OECD Stats. https://stats.oecd.org/Index.aspx?DataSetCode=EPS

Theory and Research

Porter Hypothesis (PH) suggests that stringent environmental regulation would increase both innovation and productivity (Porter and Van der Linde, 1995)

- **Strong PH:** Environmental regulation positively affects firms‘ productivity
- **Weak PH:** Environmental regulation positively affects innovative activities of the firms

Objective of the study

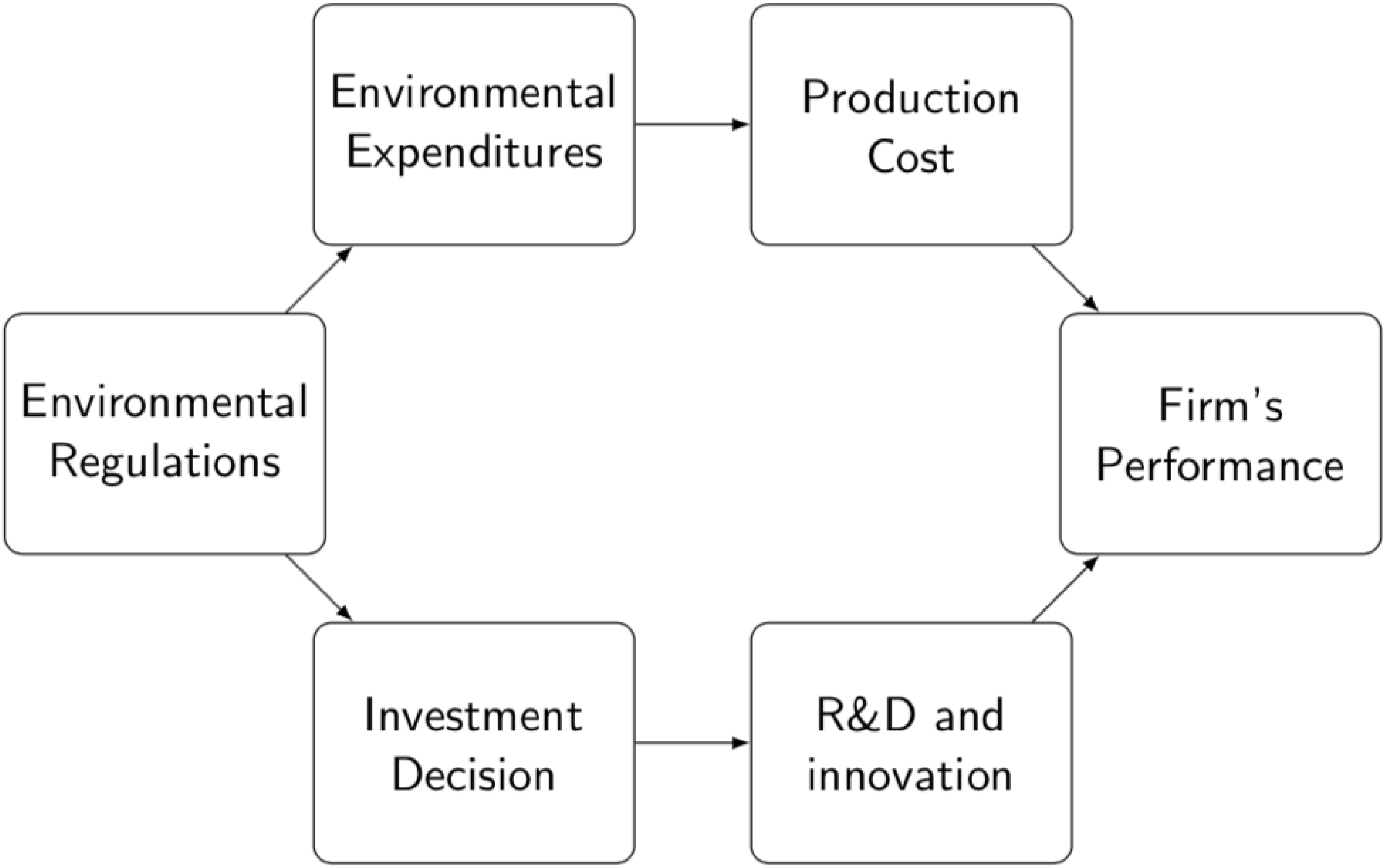
Testing the validity of the 'Weak' and 'Strong' Porter Hypotheses in Turkish manufacturing sector

Research Question:

How do environmental regulations influence innovative activities and productivity of the firms in Turkish manufacturing industry?

Theory and Research (2)

Figure 2: Environmental Regulations vs. Firms' Performance



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Literature Review (1)

Table 1: Summary of selected studies on Porter hypothesis:

	Jaffe and Palmer (1997)	Hamamoto (2006)	Lanoie et al. (2008)	Yang et al. (2012)	Rubashkina et al. (2015)	Zhao et al. (2018)
Variables	PACE R&D Patents	PACE R&D TFP	PACE TFP	PACE TFP Growth	PACE Patents TFP Growth	PACE TFP
Testing	Weak PH	Strong and Weak PH	Strong PH	Strong and Weak PH	Strong and Weak PH	Strong PH
Results	Confirms/Rejects weak PH	Confirms strong and weak PH	Confirms/ Rejects strong PH	Confirms/ Rejects weak PH Confirms strong PH	Confirms weak PH Inconclusive for strong PH	Rejects strong PH
Sample	US Manufacturing industries	Japanese manufacturing industries	Canadian manufacturing industries	Taiwanese Manufacturing Industries	European Manufacturing Sectors	Carbon intense Chinese industries

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Literature Review (2)

Summary of the results in the studies:

- Mostly sectoral analysis
- Variables used;
  - PACE is used as the main proxy for environmental regulation
  - TFP (both in levels and as growth) is used for strong PH
  - R&D and patents data are used for weak PH
- Results generally confirm weak PH; inconclusive for strong PH
- Endogeneity is the main concern

Expected contribution of our study is two-fold:

1.Literature
- contradicting results on both PHs
- our study: insights from another developing economy: Turkey

2.Literature:
- industry-level analyses
- our study: firm level study from different manufacturing sub-sectors

Data

Data is provided by Turkish Statistical Institute (TSI):

- 1. Annual Industry and Service Statistics (2009-2015)
- 2. Environmental Employment, Income and Expenditure Statistics of Enterprises (2012-2015)
- Merged data set is unbalanced panel covering 2,741 firms in 24 manufacturing industries (Section C in NACE Rev.2) for years 2012-2015.

```
      id:  2.000e+09, 2.000e+09, ..., 2.883e+09              n =       2741
    year:  2012, 2013, ..., 2015                             T =          4
           Delta(year) = 1 unit
           Span(year)  = 4 periods
           (id*year uniquely identifies each observation)

Distribution of T_i:   min      5%     25%       50%       75%     95%     max
                         1       1       1         2         3       4       4

     Freq.  Percent    Cum. |  Pattern
 ---------------------------+---------
      581     21.20   21.20 |  1111
      550     20.07   41.26 |  ...1
      266      9.70   50.97 |  1...
      197      7.19   58.15 |  ..11
      177      6.46   64.61 |  .111
      129      4.71   69.32 |  11..
      123      4.49   73.81 |  .1..
      117      4.27   78.07 |  11.1
      115      4.20   82.27 |  1.11
      486     17.73  100.00 | (other patterns)
 ---------------------------+---------
     2741    100.00         |  XXXX
```

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Empirical Model and Variables

Model Specification:

$$y_{it} = \alpha + \beta x_{it} + \theta z_{it} + \mu_i + \epsilon_{it} \quad (1)$$

Dependent variable y_{it} :

- Strong PH: either value added or labour productivity
- Weak PH: intangible assets

Indipendent variables:

- x_{it}: $pace$
- z_{it}: vector of control variables, such as firm ownership structure, export/import intensity and electricity consumption

  μ_i : individual fixed effects

  ϵ_{it} : idiosyncratic error term

Descriptive Statistics

Table 2: Summary Statistics of Variables under consideration

Variable	# of Observations	Mean	Standard Deviation	Min.	Max.
pace	6114	901242.8	13700000.0	20.0	938000000.0
value_added	6114	53900000.0	147000000.0	133.0	4040000000.0
lab_prod	6114	83479.2	126645.2	1.0	7393561.0
intangible_assets	6114	3572896.0	39200000.0	0.0	2180000000.0
foreign_ownership	5098	14.4	32.5	0.0	100.0
electricity	6114	5420757.0	17400000.0	0.0	405000000.0
export	5339	85200000.0	410000000.0	0.0	10500000000.0
import	5323	89900000.0	930000000.0	0.0	34600000000.0
total_revenue	6114	309000000.0	1340000000.0	1225941.0	43500000000.0
total_costs	6114	266000000.0	1250000000.0	35623.0	42000000000.0

Testing Strong PH - Empirical Results (1)

- Dependent variable: value added (proxy for productivity*)
- Hypothesis: positive effect of PACE on the value added
- Estimator: Fixed Effects (Hausman Stat.)

Table 3: Findings with Unbalanced panel of 2741 firms

	(1)	(2)	(3)	(4)	(5)	(6)
ln(pace)	-0.0313***	-0.0278***	-0.0307***	-0.0323***	-0.0271***	-0.0117
	(0.0084)	(0.0096)	(0.0085)	(0.0104)	(0.0100)	(0.0131)
foreign_ownership		0.0033**				0.0035***
		(0.0014)				(0.0013)
ln(electriciy)			0.1121***			0.1085***
			(0.0291)			(0.0333)
ft_ex				0.1654		0.2173*
				(0.1076)		(0.1173)
ft_im					0.6382***	0.4702***
					(0.0689)	(0.0789)
_cons	17.2279***	17.1448***	15.6402***	17.1822***	17.0749***	15.2741***
	(0.0931)	(0.1110)	(0.4157)	(0.1148)	(0.1133)	(0.4779)
F-stat	13.81***	7.20***	12.91***	5.49***	50.31***	11.63***
within R-sq	0.007	0.010	0.028	0.008	0.044	0.056
# of observations	6114	5098	6041	5339	5323	4166
Hausman Stat:	1529.60***					

Notes: robust se's are in parentheses. ***, ** and * represents significance at 1%, 5% and 10% levels.

*Results are robust when lab_prod is used instead of value-added.

Testing Weak PH - Empirical Results (2)

- Dependent variable: intangible assets (proxy for innovation)
- Hypothesis: positive effect of PACE on innovation
- Estimator: Fixed Effects (Hausman Stat.)

Table 4: Findings with Unbalanced panel of 2741 firms

	(1)	(2)	(3)	(4)	(5)	(6)
ln(pace)	-0.0772**	-0.0425	-0.0768**	-0.0531	-0.0333	0.0183
	(0.0350)	(0.0406)	(0.0350)	(0.0380)	(0.0394)	(0.0481)
foreign_ownership		0.0068*				0.0081*
		(0.0041)				(0.0043)
ln(electriciy)			0.1167*			0.2355**
			(0.0696)			(0.1110)
ft_ex				-0.0637		-0.0010
				(0.4339)		(0.5016)
ft_im					0.3397	0.3885
					(0.2760)	(0.3111)
_cons	13.1976***	12.6847***	11.5232***	12.9215***	12.6228***	8.4744***
	(0.3922)	(0.4674)	(1.0790)	(0.4384)	(0.4470)	(1.6962)
F-stat	4.87**	2.03	3.91**	1.00	1.12	2.34**
within R-sq	0.003	0.003	0.004	0.001	0.001	0.011
# of observations	4472	3666	4435	3916	3897	2997
Hausman Stat:	104.67***					

Notes: robust se's are in parentheses. ***, ** and * represents significance at 1%, 5% and 10% levels.

Treatment of Endogeneity (1)

Possible causes of endogeneity:

- bidirectional causality: value added vs. pace
- omitted factors: response vs. deliberate
- measurement errors: self-reported expenditures

(Rubashkina et al., 2015; Zhao et al. 2018)

Selection of instrument(s):

for firm i in subsector $\bar{k} \in k$

- (IV1) $\left(\frac{pace}{value\_added}\right)_{-i,\bar{\boldsymbol{k}}}$

  average share of PACE intensity for all other firms that are in the same manufacturing subsector $\bar{\boldsymbol{k}}$ as firm $\boldsymbol{i}$

- (IV2) $\left(\frac{pace}{value\_added}\right)_{-i,\boldsymbol{k}}$

  average share of PACE intensity all other firms in all sectors including subsector $\bar{\boldsymbol{k}}$

Treatment of Endogeneity (2) Strong PH First Stage Results

Table 5: Strong PH – Productivity IV regression – first stage results

First Stage Estimations	(1)	(2)	(3)	(4)	(5)	(6)
(IV1)	0.0558 (0.0397)		0.1265* (0.0678)			
L.(IV1)		-0.1685** (0.0689)	-0.1069 (0.0836)			
(IV2)				1.0345*** (0.1018)		1.7005*** (0.1527)
L.(IV2)					1.0345*** (0.1018)	-0.5219*** (0.1875)
ln(electriciy)	-0.0579 (0.0377)	-0.0614 (0.0541)	-0.0461 (0.0531)	-0.0401 (0.0370)	-0.0401 (0.0370)	0.0391 (0.0503)
ft_ex	0.1195 (0.2448)	0.9582** (0.4696)	0.9529** (0.4675)	-0.0602 (0.2411)	-0.0602 (0.2411)	0.5293 (0.3630)
ft_im	-0.5780*** (0.1602)	-1.1506*** (0.2368)	-1.1253*** (0.2371)	-0.3029* (0.1645)	-0.3029* (0.1645)	0.1090 (0.2482)
Underidentification (Kleibergen-Paap) LM test	1.95	5.20**	10.50***	93.49***	93.46***	120.673***
Weak ID (Kleibergen-Paap) F-test	1.97	5.99	6.94	103.32	103.31	83.381
Stock-Yogo weak ID test critical value (15% max IV size)	8.96	8.96	11.59	8.96	8.96	11.59
Hansen J test	NA	NA	10.39***	NA	NA	51.59***
Endogeneity chi-sqr test	8.22***	2.07	2.40	11.10***	6.39**	73.86***

Notes: robust se's are in parentheses. ***, ** and * represents significance at 1%, 5% and 10% levels.

Treatment of Endogeneity (3) Strong PH Second Stage Results

Table 6: Strong PH – Productivity IV regression – second stage results

Second Stage Estimations	(1)	(2)	(3)	(4)	(5)	(6)
lnpace (instrumented)	-0.7174	0.1538	-0.2372*	-0.1565***	-0.1225***	-0.3163***
	(0.5619)	(0.1448)	(0.1348)	(0.0415)	(0.0387)	(0.0401)
ln(electriciy)	0.0922*	0.0772	0.0562	0.1256***	0.0415*	0.0525
	(0.0552)	(0.0515)	(0.0525)	(0.0348)	(0.0245)	(0.0525)
ft_ex	0.1958	-0.4744**	-0.0987	0.1277	0.0379	-0.0214
	(0.2110)	(0.2334)	(0.2125)	(0.1113)	(0.1027)	(0.1749)
ft_im	0.2128	0.6893***	0.2361	0.5417***	0.4218***	0.1427
	(0.3534)	(0.2062)	(0.1975)	(0.0809)	(0.0721)	(0.1375)
F-stat	8.85***	6.43***	8.35***	29.85***	18.72***	23.81***
# of observations	3988	1558	1558	3989	3989	1560

Notes: robust se's are in parentheses. ***, ** and * represents significance at 1%, 5% and 10% levels.

Treatment of Endogeneity (4) Weak PH First Stage Results

Table 7: Weak PH – Innovation IV regression – first stage results

First Stage Estimations	(1)	(2)	(3)	(4)	(5)	(6)
(IV1)	0.0545		0.1742**			
	(0.0513)		(0.0713)			
L.(IV1)		-0.1117*	-0.0213			
		(0.0581)	(0.0672)			
(IV2)				1.0456***		1.6853***
				(0.1244)		(0.1711)
L.(IV2)					-0.9697***	-0.4226**
					(0.1851)	(0.1883)
ln(electriciy)	-0.0809*	-0.1405*	-0.1081	-0.0673	-0.1531**	-0.0487
	(0.0472)	(0.0763)	(0.0748)	(0.0461)	(0.0768)	(0.0642)
ft_ex	0.2111	0.8021	0.8050	0.0118	0.8983*	0.3886
	(0.2740)	(0.4905)	(0.4890)	(0.2676)	(0.4731)	(0.3793)
ft_im	-0.5065***	-0.9053***	-0.8925***	-0.1643	-0.7197***	0.2521
	(0.1839)	(0.2718)	(0.2713)	(0.1904)	(0.2737)	(0.2762)
Underidentification (Kleibergen-Paap) LM test	1.12	3.34*	9.02***	63.83***	24.57***	92.99***
Weak ID (Kleibergen-Paap) F-test	1.13	3.70	6.04	70.61	27.45	63.64
Stock-Yogo weak ID test critical value (15% max IV size)	8.96	8.96	11.59	8.96	8.96	11.59
Hansen J test	NA	NA	2.26	NA	NA	9.69***
Endogeneity chi-sqr test	1.77	0.92	0.71	0.85	2.97*	10.75***

Notes: robust se's are in parentheses. ***, ** and * represents significance at 1%, 5% and 10% levels.

Treatment of Endogeneity (5)
Weak PH Second Stage Results

Table 8: Weak PH – Innovation IV regression –second stage results

Second Stage Estimations	(1)	(2)	(3)	(4)	(5)	(6)
lnpace (instrumented)	1.7272	1.0415	-0.4321	-0.2059	0.6169	-0.5198***
	(2.0873)	(1.2895)	(0.5679)	(0.1873)	(0.4091)	(0.1672)
ln(electriciy)	0.3768*	0.1266	-0.0634	0.2171**	0.0749	-0.0715
	(0.2159)	(0.2253)	(0.1847)	(0.0977)	(0.1655)	(0.1693)
ft_ex	-0.5197	-1.5611	-0.3695	-0.1080	-1.2128	-0.2932
	(0.8551)	(1.3829)	(0.7622)	(0.4469)	(0.8338)	(0.6128)
ft_im	1.2829	1.6646	0.3098	0.2865	1.2670**	0.2213
	(1.1552)	(1.3246)	(0.7201)	(0.3061)	(0.6363)	(0.5252)
F-stat	1.29	0.67	1.03	2.41**	1.23	3.21**
# of observations	2755	1179	1179	2756	1181	1181

Notes: robust se's are in parentheses. ***, ** and * represents significance at 1%, 5% and 10% levels.

Conclusions

- negative and significant effect of PACE on value-added

  → contradicting the Strong Porter Hypothesis

  → environmental regulations negatively effects productivity of manufacturing firms

- insignificant effect of pace on intangible assets investment

  → rejecting the existence of Weak Porter Hypothesis

  → environmental regulations do not foster innovation

- redesign of regulatory policies

  → more inclusive

  → benefit rather than a burden