Environmental standards, trade and innovation: evidence from a natural experiment

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ONLINE APPENDIX

Appendix A

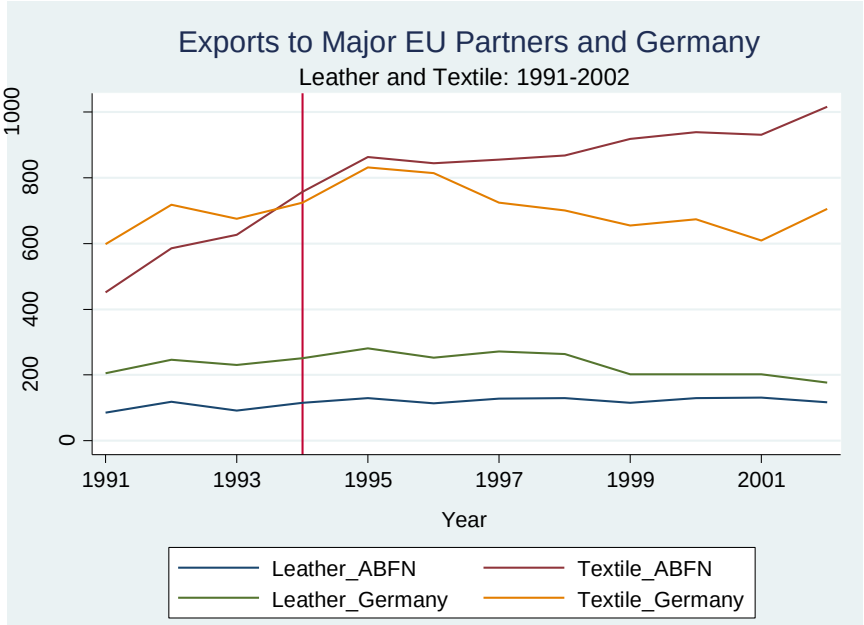

Figure A.1. *Total exports of Indian leather and textile products to Austria, Belgium, France, Netherlands (major EU partners) and Germany, 1990-2002*

Notes: Numbers represent total leather and textile products (USD million) exported in a year. "ABFN" represents Austria, Belgium, France and Netherlands.

Table A.1. *Effect of the azo-dyes regulation on leather and textile exports: using aggregate trade data*

	Exports	
	(1)	(2)
$Post_t \times lt_{ij}$	1.911***	2.322***
	(0.176)	(0.294)
$Post_t$	1.038**	–0.210
	(0.451)	(0.318)
R-square	0.18	0.19
N	286	286
Year FE	Yes	No
Time Trend	No	Yes
Industry FE(2-digit)*Time Trend	Yes	Yes

Notes: Columns (1) - (2) use a natural logarithm of exports as the dependent variable. $Post_t$ is a regulation dummy, which takes a value of 1 when the year (= t) is greater than 1994. lt_j is a sector dummy variable, which takes a value of 1 if the industrial sector j = Leather and Textiles. Other manufacturing sectors (less chemical) is used as the control group in the estimations. Numbers in parentheses are robust standard errors at the industry-level (NIC 2-digit). Intercepts are not reported. **, *** denotes 5% and 1% level of significance.

Table A.2. *Effect of the azo-dyes regulation on exports of leather and textile firms: robustness checks*

	Exports			
	Textile	Leather	1997 Regulation	Endogenous Regulation
	(1)	(2)	(3)	(4)
$Post_t \times lt_{ij}$	0.503***	0.470**	0.466***	0.299***
	(0.094)	(0.224)	(0.069)	(0.087)
$Post_{97} \times lt_{ij}$			0.013	
			(0.070)	
$Post_{t-3} \times lt_{ij}$				–0.119**
				(0.041)
$Post_{t-2} \times lt_{ij}$				–0.124***
				(0.047)
$Post_{t+1} \times lt_{ij}$				0.179***
				(0.052)
$Post_{t+2} \times lt_{ij}$				0.301***
				(0.081)
$Post_{t+3} \times lt_{ij}$				0.286***
				(0.034)
Firm Controls	Yes	Yes	Yes	Yes
R-square	0.42	0.41	0.42	0.42
N	31404	27103	31786	31786
Industry FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Industry FE(2-digit)*Time Trend	Yes	Yes	Yes	Yes

Notes: The dependent variable is the natural logarithm of exports plus 1. $Post_t$ is a regulation dummy, which takes a value of 1 when the year (= t) is greater than 1994. lt_{ij} is a dummy variable, which takes a value of 1 if a firm i belongs to the industrial sector j (= Leather and Textiles). $Post_{97}$ is a regulation dummy, which takes a value of 1 when the year ($= t$) is greater than 1997. Other manufacturing sectors (less chemical) is used as the control group in the estimations. $Post_{t-2}$ and $Post_{t-3}$ takes a value of 1 the year which is equal to two and three years less than the year of the regulation, respectively. $Post_{t+1}$, $Post_{t+2}$ and $Post_{t+3}$ takes a value of 1 if the year is equal to one, two and three years following the regulation, respectively. All the regressions include the individual terms of the double interactions. Firm controls include age of a firm, age squared, size ownership (domestic or foreign) indicator of a firm. 'Assets' is used as the size indicator of a firm. Numbers in parentheses are clustered standard errors at the industry-level. Intercepts are not reported. **,*** denotes 5% and 1% level of significance.

Table A.3. *Effect of the azo-dyes regulation on exports of leather and textile firms: additional checks*

	Exports				
	Aggregate			Quartile	
	TFP	Plant & Machinery	Industry FE* Time Dummies	Import of Raw Materials	Technology Transfer
	(1)	(2)	(3)	(4)	(5)
$Post_t \times lt_{ij}$	0.322***	0.480**	0.841***		
	(0.082)	(0.069)	(0.018)		
$Post_t \times lt_{ij} \times$ TFP94	–0.012				
	(0.050)				
$Post_t \times lt_{ij} \times$ PlantMach94		0.114			
		(0.079)			
Assets	0.622***	0.621***	0.622***		
	(0.063)	(0.069)	(0.060)		
$Post_t \times lt_{ij} \times$ 1st Quartile				–0.012	0.028
				(0.037)	(0.177)
$Post_t \times lt_{ij} \times$ 2nd Quartile				0.048	0.088
				(0.040)	(0.126)
$Post_t \times lt_{ij} \times$ 3rd Quartile				0.055	0.013
				(0.054)	(0.113)
$Post_t \times lt_{ij} \times$ 4th Quartile				0.064**	–0.062
				(0.032)	(0.050)
$Post_t \times lt_{ij} \times$ 1st Quartile × ImpRawMat94				–0.031	
				(0.072)	
$Post_t \times lt_{ij} \times$ 2nd Quartile × ImpRawMat94				0.018	
				(0.082)	
$Post_t \times lt_{ij} \times$ 3rd Quartile × ImpRawMat94				0.039	
				(0.049)	
$Post_t \times lt_{ij} \times$ 4th Quartile × ImpRawMat94				0.074**	
				(0.031)	
$Post_t \times lt_{ij} \times$ 1st Quartile × TechTransfer94					–0.002
					(0.446)
$Post_t \times lt_{ij} \times$ 2nd Quartile × TechTransfer94					–0.058
					(0.371)
$Post_t \times lt_{ij} \times$ 3rd Quartile × TechTransfer94					0.351***
					(0.129)
$Post_t \times lt_{ij} \times$ 4th Quartile × TechTransfer94					0.015
					(0.110)
Firm Controls	Yes	Yes	Yes	Yes	Yes
R-square	0.45	0.46	0.43	0.47	0.47
N	19208	17695	31786	17653	4931

Industry FE	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes
Industry FE(2-digit)*Time Trend	Yes	Yes	No	Yes	Yes
Industry FE(2-digit)*Year Dummies	No	No	Yes	No	No

Notes: Columns (1) - (4) use a natural logarithm of exports plus 1 as the dependent variable. $Post_t$ is a regulation dummy, which takes a value of 1 when the year (= t) is greater than 1994. lt_{ij} is a dummy variable, which takes a value of 1 if a firm i belongs to the industrial sector j (= Leather and Textiles). Other manufacturing sectors (less chemical) is used as the control group in the estimations. 'TFP94' is the average level of firm productivity measure, estimated by Levinshon and Petrin's (2003) methodology, between 1990 and 1993 (before the regulation). 'PlantMach94' is the average amount of expenses for plant and machinery and its repairs by a firm between 1990 and 1993 (before the regulation). 'ImpRawMat94' is the average amount of raw material imported by a firm between 1990 and 1993 (before the regulation). 'TechTransfer94' is the average amount of royalty payment made by a firm for technical knowhow between 1990 and 1993 (before the regulation). All the regressions include the individual and double interaction terms of the double and triple interactions, respectively. Firm controls include age of a firm, age squared, ownership (domestic or foreign) and size indicator of a firm. 'Assets' of a firm is used as the size indicator. Numbers in parentheses are clustered standard errors at the industry-level. Intercepts are not reported. **, *** denotes 5% and 1% level of significance.

Table A.4. *Effect of the azo-dyes regulation on import of raw materials of leather and textile firms: robustness checks*

	Import of Raw Materials				
	One Year Before & After the Regulation	Textile	Leather	1997 Regulation	Endogenous Regulation
	(1)	(2)	(3)	(4)	(5)
$Post_t \times lt_{ij}$	0.473***	0.171**	–0.066	0.177**	0.156*
	(0.120)	(0.082)	(0.067)	(0.087)	(0.085)
$Post_{97} \times lt_{ij}$				–0.039	
				(0.074)	
$Post_{t-3} \times lt_{ij}$					–0.259**
					(0.130)
$Post_{t-2} \times lt_{ij}$					–0.027
					(0.037)
$Post_{t+1} \times lt_{ij}$					0.046
					(0.060)
$Post_{t+2} \times lt_{ij}$					0.163
					(0.222)
$Post_{t+3} \times lt_{ij}$					0.056
					(0.141)
Firm Controls	Yes	Yes	Yes	Yes	Yes
R-square	0.45	0.46	0.47	0.46	0.46
N	6809	31404	27103	31786	31786
Firm FE	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes
Industry FE(2-digit)*Time Trend	Yes	Yes	Yes	Yes	Yes

Notes: The dependent variable is the natural logarithm of import of raw materials plus 1. $Post_t$ is a regulation dummy, which takes a value of 1 when the year (= t) is greater than 1994. lt_{ij} is a dummy variable, which takes a value of 1 if a firm i belongs to the industrial sector j (= Leather and Textiles). $Post_{97}$ is a regulation dummy, which takes a value of 1 when the year (= t) is greater than 1997. Other manufacturing sectors (less chemical) is used as the control group in the estimations. $Post_{t-2}$ and $Post_{t-3}$ takes a value of 1 the year which is equal to two and three years less than the year of the regulation, respectively. $Post_{t+1}$, $Post_{t+2}$ and $Post_{t+3}$ takes a value of 1 if the year is equal to one, two and three years following the regulation, respectively. All the regressions include the individual terms of the double interactions. Firm controls include age of a firm, age squared, size ownership (domestic or foreign) indicator of a firm. 'Assets' is used as the size indicator of a firm. Numbers in parentheses are clustered standard errors at the industry-level. Intercepts are not reported. *, **, *** denotes 10%, 5% and 1% level of significance.

Table A.5. *Effect of the azo-dyes regulation on technology transfer of leather and textile firms: robustness checks*

	Technology Transfer				
	One Year Before & After the Regulation	Textile	Leather	1997 Regulation	Endogenous Regulation
	(1)	(2)	(3)	(4)	(5)
$Post_t \times lt_{ij}$	–0.329	0.164	–0.317**	0.039	0.092
	(0.204)	(0.181)	(0.154)	(0.150)	(0.167)
$Post_{97} \times lt_{ij}$				0.118	
				(0.302)	
$Post_{t-3} \times lt_{ij}$					–0.023
					(0.175)
$Post_{t-2} \times lt_{ij}$					–0.041
					(0.075)
$Post_{t+1} \times lt_{ij}$					0.017
					(0.095)
$Post_{t+2} \times lt_{ij}$					0.223
					(0.299)
$Post_{t+3} \times lt_{ij}$					0.107
					(0.231)
Firm Controls	Yes	Yes	Yes	Yes	Yes
R-square	0.41	0.41	0.41	0.41	0.41
N	1084	4568	4379	4603	4603
Firm FE	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes
Industry FE(2-digit)*Time Trend	Yes	Yes	Yes	Yes	Yes

Notes: The dependent variable is the natural logarithm of technology transfer plus 1. $Post_t$ is a regulation dummy, which takes a value of 1 when the year (= t) is greater than 1994. lt_{ij} is a dummy variable, which takes a value of 1 if a firm i belongs to the industrial sector j (= Leather and Textiles). $Post_{97}$ is a regulation dummy, which takes a value of 1 when the year ($= t$) is greater than 1997. Other manufacturing sectors (less chemical) is used as the control group in the estimations. $Post_{t-2}$ and $Post_{t-3}$ takes a value of 1 the year which is equal to two and three years less than the year of the regulation, respectively. $Post_{t+1}$, $Post_{t+2}$ and $Post_{t+3}$ takes a value of 1 if the year is equal to one, two and three years following the regulation, respectively. All the regressions include the individual terms of the double interactions. Firm controls include age of a firm, age squared, size ownership (domestic or foreign) indicator of a firm. 'Assets' is used as the size indicator of a firm. Numbers in parentheses are clustered standard errors at the industry-level. Intercepts are not reported.
** denotes 5% level of significance.

Appendix B

Productivity Estimation

Using Levinshon and Petrin (2003) (LP (2003), hereafter), we construct a consistent firm level measure of Total Factor Productivity (TFP). Levinshon and Petrin (2003) uses firms' 'expenditure on raw material inputs' to correct for the simultaneity in a firm's production function. The inclusion of this proxy in the estimation equation, which controls part of the error correlated with the inputs, ensures that the variation in inputs related to the productivity will be eliminated. LP (2003) shows that if the demand function for intermediate inputs is monotonic in a firm's productivity for all relevant levels of capital, then raw materials can serve as a valid proxy. Assuming a Cobb-Douglas production function, the equation estimated in the first-step for a firm i in industry j at time t can be written as follows:

$$Y_{ijt} = \hat{A}_{ijt} L_{ijt}^{\theta_l} K_{ijt}^{\theta_k} Q_{ijt}^{\theta_q}$$

or

$$y_{ijt} = \theta_l l_{ijt} + \theta_k k_{ijt} + \theta_q q_{ijt} + \omega_{ijt} + \epsilon_{ijt},$$

where lower caps symbolize the variables in natural logarithm. Y_{ijt} represents output of firm i in industry j at time t; L_{ijt}, K_{ijt}, and Q_{ijt} denotes labour, capital and power, fuel and electricity expenditures, respectively. $\hat{A}_{ijt} = A^{\theta_q}$ is the productivity of a firm. Therefore, we can write the above equation as:

$$va_{ijt} = \theta_l l_{ijt} + \theta_k k_{ijt} + \omega_{ijt} + \epsilon_{ijt},$$

where $va_{ijt} = y_{ijt} - \theta_q q_{ijt}$ signifies the natural logarithm of value added. ω_{ijt} is the firm level TFP measure and is unobservable to the econometrician, while ϵ_{ijt} is the classical error term. Using Ordinary Least Squares (OLS) to estimate the above equation will lead to biased coefficients, since the input choice for each firm will be correlated with its productivity level. For example, if more productive firms are the ones which are more capital intensive, then

OLS on the above equation will lead to a downward bias on θ_k and an upward bias on the remaining coefficients. On the other hand, a standard fixed effects estimator will ignore time-varying shocks to productivity. As a result, to obtain consistent estimates of the input coefficients in the above equation, we use the LP (2003) methodology.

The highlight of this approach is its ability to account for the simultaneity between input choices and productivity. The LP (2003) method is a semi-parametric technique based on a dynamic profit maximization problem in which the firm, if it decides to remain in the market, must choose the level of labour and intermediate inputs to employ at time t. The intermediate input demand function can be written as $q_{ijt} = q_t(k_{ijt}, \omega_{ijt})$. Assuming intermediate input use to be positive and monotonically increasing in productivity, we invert the input demand function to obtain the following expression $\omega_{ijt} = \omega_t(k_{ijt}, q_{ijt})$. This allows us to proxy for the unobservable productivity variable in the value-added equation, with a function of capital and proxy for intermediate inputs. Following LP (2003), we use 'power, fuel and electricity expenditures' at the firm level as the choice for the intermediate input. This yields an estimate for the coefficient of labour. In the second stage, the coefficient for capital is obtained using the assumption that the productivity follows a first-order Markov process. The production function estimates obtained from the LP (2003) methodology are then used to calculate the log of TFP for each firm by using the following:

$$tfp_{ijt} = va_{ijt} - \theta_l l_{ijt} - \theta_k k_{ijt},$$

where θ_l and θ_k are actual estimated coefficients of labour and capital, respectively. Table B.1 compares OLS, Fixed Effects (FE) and LP's capital and labour estimates of the production function. As expected, both OLS and FE overestimate the coefficients for labour and underestimate the coefficient for capital. The underestimation of capital is especially acute in the case of the fixed effects estimation.

Table B.1. *Production function estimates*

	Capital			Labour		
	OLS	FE	LP	OLS	FE	LP
Textile and Leather Firms	0.457	0.301	0.728	0.530	0.533	0.463

Notes: Author's calculation.

References

Levinshon, J. and A. Petrin (2003), 'Estimating production functions using inputs to control for unobservables', *The Review of Economic Studies* **70**(2): 317-342.