The Changing Patterns of the Canadian Industries Energy Intensity

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Order of the presentation

1- Introduction

2- The model

3- Some statistical information

4- The results

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1- Introduction

- Are manufacturing industries becoming more or less energy intensive?

- Why it matters?

2- The model

a) The economic model

Energy demand fonction

$$E = H(Q, p_E, T) \qquad (1)$$

where E = energy

Q = output

p_E = real price of energy

T = state of Technology

$e = E / Q$ = energy intensity $\qquad$ (2)

2- The model

$$\frac{\dot{e}}{e} = (\xi_{E:Q} - 1)\frac{\dot{Q}}{Q} + \xi_{E:p_E}\frac{\dot{p}_E}{p_E} + \xi_{E:T}\frac{\dot{T}}{T} \qquad (3)$$

where a dot above a variable indicates the time derivative; for instance $\dot{e} = \frac{de}{dt}$

$\xi_{Y:X}$ = elasticity of variable Y with respect to X

2- The model

b) The statistical model

$$y_{ij} = \alpha_i + \gamma_j + \sum_{k=1}^{K} (\beta_k + \upsilon_{ik})x_{ij}^k + \varepsilon_{ij} \qquad (4)$$

where i = industry $i = (1,...,18)$

j = provine $j = (1,...,4)$

y_{ij} = rate of change of energy intensity

x_{ij}^k = rate of change of the kth explanotary variable

α_i , γ_j , β_k are fixed coefficients

υ_{ik} = independent random variable $N(0, \sigma_k^2)$

ε_{ij} = independent random error $N(0, \sigma_\varepsilon^2)$

2- The model

(4) can be written as

$$y_{ij} = \alpha_i + \gamma_j + \sum_{k=1}^{K} \beta_k x_{ij}^k + \varepsilon_{ij} + \sum_{k=1}^{K} \upsilon_{ik} x_{ij}^k \qquad (5)$$

$$= \alpha_i + \gamma_j + \sum_{k=1}^{K} \beta_k x_{ij}^k + \varepsilon_{ij}^* \qquad (6)$$

where
$$\varepsilon_{ij}^* = \varepsilon_{ij} + \sum_{k=1}^{K} \upsilon_{ik} x_{ij}^k \qquad (7)$$

2- The model

- The set of explanotary variables is:
  - rate of change of ouput
  - rate of change of (price of energy / price of capital goods)
  - rate of change of (price of energy / price of labour)
  - rate of change of (RD expenditures /output)
  - rate of change of net exports

3- Some Statistical information

TABLE 1

Average value added (M$ 1992) - Average share of manufacturing sector (%) - Annualized growth rate (%) from 1976 to 1996

	Total manufacturing*	Food and beverage	Rubber and plastic products	Leather and allied products	Primary textiles and textile products**	Clothing***	Wood	Furniture and fixture	Paper and allied products	Printing, publishing	Primary metal	Fabricated metal products	Machinery	Transportation equipment	Electrical and electronic products	Non-metallic mineral products	Refined petroleum and coal	Chemical products	Other manufacturing
Québec	24 927.7	3 499.3	i.d.	226.4	1 062.1	1 644.8	1 051.6	612.8	1 920.9	1 938.1	1 489.6	1 608.8	853.9	2 091.9	1 321.6	662.5	166.7	1 648.8	i.d.
	100.0	14.0		0.9	4.3	6.6	4.2	2.5	7.7	7.8	6.0	6.5	3.4	8.4	5.3	2.7	0.7	6.6	
	1.9	0.0		-1.3	1.1	0.3	3.9	-0.2	1.8	0.1	4.1	0.2	2.6	5.7	7.0	-1.4	1.0	3.0	
Ontario	47 777.5	6 124.3	1 805.8	280.7	1 011.5	976.0	784.9	1 031.1	1 784.7	3 741.4	2 707.3	4 162.4	2 724.6	8 712.7	2 992.7	1 411.2	318.9	3 652.4	i.d.
	100.2	12.8	3.8	0.6	2.1	2.0	1.6	2.2	3.7	7.8	5.7	8.7	5.7	18.2	6.3	3.0	0.7	7.6	
	1.9	0.7	3.8	-9.9	0.5	2.3	3.0	1.3	1.6	0.6	0.6	0.7	1.2	4.0	5.5	-0.8	0.2	2.7	
Alberta	5 219.9	987.9	i.d.	i.d.	i.d.	66.7	297.6	93.2	206.8	457.0	193.8	446.6	349.7	108.6	152.0	333.3	136.3	861.0	95.9
	100.0	18.9				1.3	5.7	1.8	4.0	8.8	3.7	8.6	6.7	2.1	2.9	6.4	2.6	16.5	1.8
	4.6	1.8				-0.1	5.6	3.9	5.3	1.4	3.0	3.3	5.3	0.0	14.2	-0.3	6.8	10.2	5.5
B.C.	8 458.1	1 142.8	i.d.	i.d.	35.6	97.2	2 073.4	80.5	1 180.0	558.5	316.3	507.2	325.8	351.0	145.6	269.6	102.5	244.7	108.8
	100.0	13.5			0.4	1.1	24.5	1.0	14.0	6.6	3.7	6.0	3.9	4.2	1.7	3.2	1.2	2.9	1.3
	0.9	1.2			6.0	1.6	0.6	1.5	-2.0	1.2	-0.5	1.8	3.2	0.4	9.9	1.6	-1.3	1.8	5.0

i.d.: Incomplete data.

**Data from 1992 to 1996 are missing for B.C.

* Total manufacturing may exceed the sum of the industries since some industries are left out. *** Data from 1976 to 1978 are missing for Alberta.

TABLE 2
Average share of energy costs in production value (%)
The leading energy source: It's share of energy costs (%)
from 1976 to 1996

	Total manufacturing	Food and beverage	Rubber and plastic products	Leather and allied products	Primary textiles and textile products*	Clothing**	Wood	Furniture and fixture	Paper and allied products	Printing, publishing	Primary metal	Fabricated metal products	Machinery	Transportation equipment	Electrical and electronic products	Non-metallic mineral products	Refined petroleum and coal	Chemical products	Other manufacturing
Québec	3.13	1.59	i.d.	0.84	2.69	0.62	2.80	2.80	9.50	0.71	8.03	1.58	1.22	0.94	0.95	8.76	1.81	3.99	i.d.
	E	E		E	E	E	E	E	E	E	E	E	E	E	E	G	G	E	
	57.9	39.7	i.d.	71.8	52.4	68.6	62.4	61.2	67.2	72.1	55.3	48.5	56.3	52.9	68.6	33.7	55.1	65.5	
Ontario	2.24	1.56	2.34	1.24	3.00	0.70	2.82	1.21	6.27	0.82	5.36	1.62	1.06	0.80	0.92	7.35	1.83	4.96	i.d.
	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E	G	E	
	52.3	43.5	68.7	53.2	49.7	63.2	52.7	53.9	54.0	66.6	56.6	51.3	55.0	62.2	65.2	39.7	50.9	44.7	
Alberta	2.69	1.13	i.d.	i.d.	i.d.	0.80	2.67	1.10	4.33	0.89	3.97	1.34	1.14	1.15	0.54	5.99	1.63	7.94	0.96
	G	E				E	E	E	E	E	G	E	E	E	E	G	G	G	E
	54.1	47.7				63.3	50.8	60.3	54.9	73.5	50.5	54.3	52.3	53.1	77.8	47.8	61.6	70.2	68.4
B.C.	3.30	1.24	i.d.	i.d.	1.03	0.53	2.46	1.10	9.07	0.73	2.30	1.31	1.05	0.80	0.74	7.11	1.18	6.76	1.09
	E	E			E	E	E	E	E	E	G	E	E	E	E	G	G	E	E
	53.5	45.0			74.4	68.3	59.2	68.5	53.3	73.6	46.8	57.8	64.8	54.3	76.5	40.5	52.8	81.6	55.2

i.d.: incomplete data

* Data from 1992 to 1996 are missing for B.C.

** Data from 1976 to 1978 are missing for Alberta

E: electricity

G: natural gas

TABLE 3

Real price change of energy sources in total manufacturing from 1976 to 1996

(%)

Energy Source	Québec	Ontario	Alberta	British Columbia
Coal	-40.0	-51.0	29.6	-67.2
Natural gas	-16.6	-16.7	-7.0	-16.0
Electricity	43.6	50.6	14.5	55.5
Oil products	40.7	51.2	7.9	40.6
Theil price index	28.6	23.0	6.9	24.3

TABLE 4

Annualized growth rate of energy intensity indicators from 1976 to 1996 in Québec

(%)

	Theil quantity index divided by			Joules divided by			
	Production Value	Shipments Value	Value Added	Production Value	Shipments Value	Value Added	
Total manufacturing	0.17	0.15	0.07	-0.11	-0.14	-0.21	?
Food and beverage	-0.29	-0.29	0.20	-0.57	-0.58	-0.09	?
Leather	3.10	2.66	1.49	2.12	1.68	0.51	+
Primary textiles and textile products	-1.23	-1.28	-1.45	-1.62	-1.67	-1.84	-
Clothing	3.59	3.54	4.34	4.37	4.32	5.12	+
Wood	0.55	0.53	0.52	0.53	0.51	0.50	+
Furniture and fixture	1.25	1.19	1.80	1.67	1.62	2.22	+
Paper and allied products	-1.79	-1.44	-1.91	-1.44	-1.09	-1.56	-
Printing and publishing	3.82	3.82	4.73	3.45	3.45	4.36	+
Primary metal	0.98	0.97	1.11	0.71	0.69	0.84	+
Fabricated metal products	1.63	2.04	2.25	1.31	1.72	1.92	+
Machinery	-1.31	-1.29	-0.97	-1.81	-1.79	-1.46	-
Transportation equipment	-2.74	-2.71	-3.94	-3.22	-3.19	-4.42	-
Electrical and electronic products	-3.62	-3.60	-4.31	-4.46	-4.44	-5.16	-
Non-metallic mineral products	-1.88	-1.95	-1.02	-1.37	-1.44	-0.51	-
Refined petroleum and coal	5.81	5.71	2.63	6.32	6.21	3.13	+
Chemical products	-0.78	-0.83	-1.17	-1.15	-1.21	-1.54	-

TABLE 5
Annualized growth rate of energy intensity indicators from 1976 to 1996 in Ontario
(%)

	Theil quantity index divided by			Joules divided by			
	Production Value	Shipments Value	Value Added	Production Value	Shipments Value	Value Added	
Total manufacturing	-2.41	-2.52	-2.01	-2.88	-3.00	-2.48	-
Food and beverage	-3.81	-3.92	-3.21	-1.59	-1.70	-1.00	-
Rubber and plastic products	-1.94	-2.10	-2.15	-3.28	-3.43	-3.48	-
Leather and allied textile products	1.10	0.85	4.19	-0.17	-0.42	2.92	?
Primary textiles and textile products	-1.62	-1.84	-2.29	-2.59	-2.82	-3.26	-
Clothing	1.45	2.27	1.53	1.62	2.44	1.71	+
Wood	-1.13	-1.31	-1.23	-1.20	-1.38	-1.30	-
Furniture and fixture	-0.96	-1.16	-0.30	-1.28	-1.48	-0.62	-
Paper and allied products	-0.97	-0.81	-1.05	-1.43	-1.27	-1.50	-
Printing and publishing	0.60	0.46	1.64	0.40	0.26	1.44	+
Primary metal	-1.43	-1.60	-1.13	-1.80	-1.97	-1.50	-
Fabricated metal products	0.13	0.28	0.14	0.47	0.61	0.48	+
Machinery	-2.32	-2.50	-2.46	-3.14	-3.32	-3.28	-
Transportation equipment	-1.99	-2.03	-1.35	-2.32	-2.35	-1.68	-
Electrical and electronic products	-4.45	-4.60	-5.59	-5.22	-5.37	-6.36	-
Non-metallic mineral products	-1.64	-1.61	-0.72	-1.44	-1.41	-0.51	-
Refined petroleum and coal	2.89	2.89	3.10	3.25	3.25	3.46	+
Chemical products	-3.88	-4.01	-4.40	-4.73	-4.86	-5.25	-

TABLE 6

Annualized growth rate of energy intensity indicators from 1976 to 1996 in Alberta

(%)

	Theil quantity index divided by			Joules divided by			
	Production Value	Shipments Value	Value Added	Production Value	Shipments Value	Value Added	
Total manufacturing	0.64	0.54	0.03	0.55	0.45	-0.06	?
Food and beverage	0.09	0.02	0.52	0.24	0.17	0.68	+
Clothing*	2..15	2.28	3.86	3.51	3.63	5.21	+
Wood	1.11	0.90	-0.55	0.60	0.39	-1.07	?
Furniture and fixture	2.21	2.09	3.06	3.44	3.31	4.28	+
Paper and allied products	0.05	0.27	0.17	-2.44	-2.23	-2.33	?
Printing and publishing	3.43	3.28	4.52	3.49	3.34	4.58	+
Primary metal	-0.31	-0.44	-1.31	-1.89	-2.01	-2.89	-
Fabricated metal products	3.90	4.43	4.10	4.41	4.94	4.61	+
Machinery	-3.59	-3.82	-2.02	-2.64	-2.87	-1.07	-
Transportation equipment	4.24	4.06	3.14	4.40	4.21	3.30	+
Electrical and electronic products	-8.15	-8.06	-9.81	-10.31	-10.22	-11.97	-
Non-metallic mineral products	0.83	0.68	1.74	0.33	0.18	1.24	+
Refined petroleum and coal	-1.05	-0.98	-4.73	-0.77	-0.70	-4.45	-
Chemical products	-1.54	-1.89	-2.69	-0.68	-1.04	-1.83	-
Other manufacturing	1.20	0.95	0.82	2.29	2.03	1.91	+

* Data from 1976 to 1978 are missing

TABLE 7

Annualized growth rate of energy intensity indicators from 1976 to 1996 in British Colombia

(%)

	Theil quantity index divided by			Joules divided by			
	Production Value	Shipments Value	Value Added	Production Value	Shipments Value	Value Added	
Total manufacturing	-1.10	-1.23	-0.21	-0.94	-1.07	-0.05	-
Food and beverage	0.35	0.10	1.37	0.64	0.40	1.67	+
Textile*	-7.99	-7.88	-10.01	-8.11	-7.99	-10.13	-
Clothing	1.40	1.26	2.92	3.25	3.11	4.77	+
Wood	0.42	0.33	1.78	0.91	0.82	2.27	+
Furniture and fixture	3.67	3.45	4.53	5.67	5.46	6.53	+
Paper and allied products	0.47	0.55	2.93	0.09	0.17	2.55	+
Printing and publishing	0.70	0.58	1.61	3.04	2.92	3.96	+
Primary metal	-7.53	-8.19	-7.54	-4.02	-4.68	-4.03	-
Fabricated metal products	2.15	2.53	2.76	2.12	2.51	2.74	+
Machinery	0.58	0.47	0.76	5.07	4.96	5.25	+
Transportation equipment	4.24	4.18	4.99	4.17	4.12	4.93	+
Electrical and electronic products	-3.66	-3.62	-6.37	-3.47	-3.43	-6.18	-
Non-metallic mineral products	-2.56	-2.63	-1.57	-1.11	-1.19	-0.12	-
Refined petroleum and coal	-0.60	-1.19	-1.20	-0.46	-1.04	-1.05	-
Chemical products	-2.34	-2.47	-2.80	-1.83	-1.96	-2.29	-
Other manufacturing	1.22	1.05	1.04	3.57	3.40	3.39	+

4- The results

Variable	Period 1 1976 - 1985		Period 2 1986 - 1996	
	Coefficient	t-stat	Coefficient	t-stat
Constant	0.065	5.813	-0.025	-1.415
Québec	-0.005	-0.634	0.021	1.125
Ontario	-0.025	-3.543	0.029	1.569
Alberta	0.023	2.359	0.019	1.313
Paper and allied products	-0.009	-0.476	0.023	1.714
Primary metal	-0.012	-0.943	-0.015	-0.694
Non-metallic mineral products	-0.001	-0.054	-0.002	-0.082
Chemical products	0.008	0.379	-0.035	-2.252
Output	0.048	1.072	-0.274	-1.748
Energy price / capital price	-1.935	-6.816	-1.033	-2.251
Energy price / labour price	0.458	4.756	0.117	0.944
RD / output	0.039	1.048	0.297	2.304
Net exports	0.016	2.114	0.206	1.329

5- Conclusion