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eec2 Environmental Economics and Climate Change

ESTIMATING THE VALUE OF WATER IN THE CHILEAN INDUSTRY: A MARGINAL PRODUCTIVITY APPROACH

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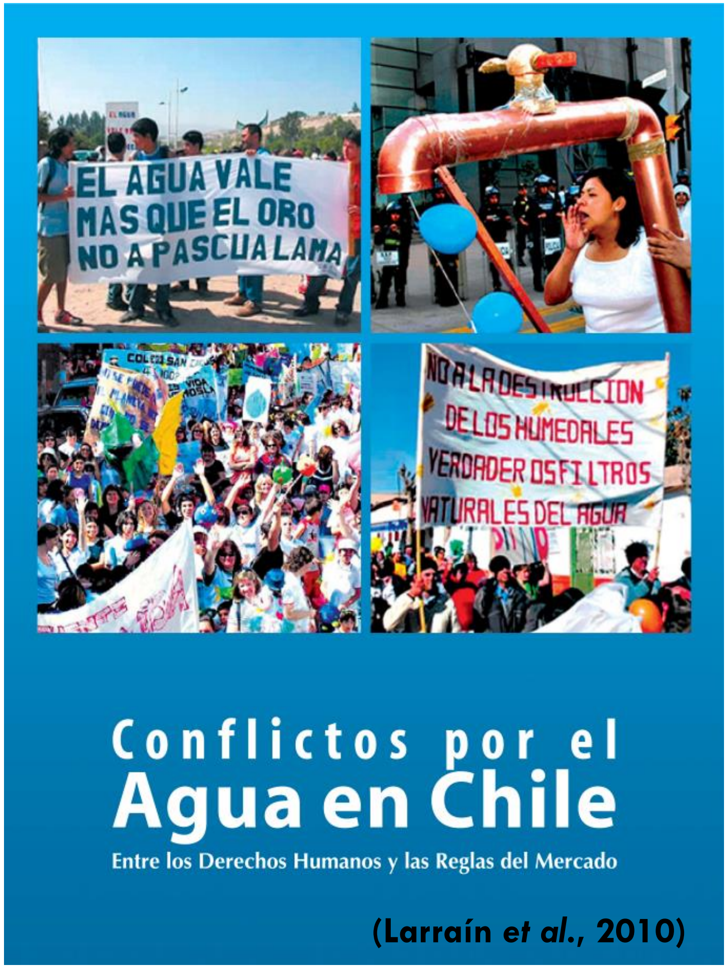
Introduction: Water situation in Chile

- “Scarcity” of water property rights (DGA, 1999; Salazar, 2003; UChile, 2010)
- Droughts have decreased significantly water availability for Hydroelectric generation (DGA, 1999; UChile, 2010).
- Reduction in Wetlands (Larraín et al., 2010)
- Several Water conflicts



(Larraín *et al.*, 2010)

Water consumption in Chile

Use (m3/s)/Year	Offstream				Instream	Source
	Agro-forestry	Residential	Industrial	Mining	Electricity	
1990	515.8	27.4	47.1	43.2	1189	UChile, 2013
%	81.4	4.3	7.4	6.8	100	
1991	-	-	-	-	-	UChile, 2002
%	85	4	6	5	100.0	
1995	546	30	53	46	1603.0	DGA, 1996
%	80.9	4.4	7.9	6.8	100.0	
1998	546	35.0	45.5	32.5	1387.6	DGA, 1999
%	82.9	5.3	6.9	4.9	100	
1999	611.4	34.1	68.2	50.5	2914	UChile, 2013
%	80.0	4.5	8.9	6.6	100.0	
2002	647.0	36.7	77.2	53.2	3929	UChile, 2013
%	79.5	4.5	9.5	6.5	100	
2006	526.7	40.1	83.8	62.8	3997.2	UChile, 2013
%	73.8	5.6	11.8	8.8	100	
2010	-	-	-	-	-	UChile, 2013
%	73	6	12	9	100	
2014	-	-	-	-	-	DGA, 2014
%	64.6*	9.2*	12.4*	13.8*	100	
2017	-	-	-	-	-	Matus, 2004
%	76.9	4.7	12.2	6.2	100	
2030	-	-	-	-	-	UChile, 2013
%	60	5	26	9	100	

Why to value water?

- The Economic value of water can have several uses in public policy
  - Cost-benefit analysis of project that affect water quantity or quality.
  - Contribute to prioritize water uses according to their economic and social value.
  - Promote efficient use of water.
  - Allow to evaluate policy at a basin scale contrasting industrial, agricultural, forestry and residential uses.
  - Calculation of compensation at industrial level in the context of social conflicts in water use.
  - Experimental ecosystem services accounting.

Objective

- To estimate the Economic value of water for the industrial sector in Chile.

Literature Review

- **Ghosh (2009)** : General review of economic value of water for three uses: Residential, industrial and Agriculture, Ecosystems,

- **Frederick (1996): Meta analysis** for the USA reporting 494 estimations of the economic value of water.

- **DeGispert (2004)**: evaluate the implication of different tariff structure in the industrial sector.

Literature Review

- W=f(Average price). OLS, GLS.
- Correcting W estimation for selection bias.
- Estimate Cost function on Q and other inputs prices.
- SURE system of inputs demands.
- Equation cost system for W_T, W_R, W_D y W_I, (LS3S).
- Production function Q=F(inputs).
- Others.

Paper: Year-1st author	Geographic Zone	Approach	Direct input-price elasticity of W_I
1969-Rees	UK, SE England	Water demand	-
1969-Turnovsky	USA, Massachusetts	Water demand	-0.50/0.63
1973-Oh	USA, Hawaii, Honolulu	Water demand by locality	-1.67/0.28
1974-De-Rooy	USA, New Jersey	Water demand	-0.89/-0.74
1979-Grebenstein	USA	Total costs	-0.80/-0.33
1982-Babin	USA	Total costs	-0.66/0.14
1984-Ziegler	USA, Arkansas	2 water demand eq.: a) with average price, b) with marginal price	-0.08
1986-William	USA	Water demand by locality	-0.97/-0.44
1988-Renzetti	Canada, B. Columbia	System of cost equations	-0.54-0.12
1990-Renzetti	Canada, B. Columbia	System of cost equations	-1.91
1991-Schneider	USA, Columbus	Water demand by locality	-0.15/-0.59
1992-Renzetti	Canada	Water costs	-0.59/-0.15
1993-Renzetti	Canada	2 stages. 1) Decision supply; 2) 2 water demand eq.: a) private supply, b) public supply	a)-1.14/-0.05 b)-2.17/-0.65
1998-Dupont	Canada	Water costs	-0.38/-0.26
1999-Malla	USA, Hawaii	2 water demand eq.: a) total, b) consumed by jobs	-0.37
2001-Dupont	Canada	2 total costs eq.: a) quasi-fix water, b) variable water	-0.78
2001-Onjala	Kenia	Water demand (dynamic adjustment)	-0.60/-0.37
2002-Hussaina	Sri Lanka	Water demand	-1.34
2002-Wang	China	Total production	-1.20/-0.57
2003-Feres	Brazil, Sao Paulo	Total costs	-1.18/-1.06
2003-Renzetti	Canada	Total costs	-0.13
2003-Reynaud	France, Gironde	Water costs	W_A)-2.21/-0.90 * W_N)-0.79/-0.10 *
2005-Feres	Brazil, Sao Paulo	Total costs	-1.16/-1.02**
2006-Kumar	India	Distance factors	-0.94/-0.30
2006-Liaw	China, Taiwan	Total costs (engineering)	-4.37/-0.02
2010-Bruneau	Canada	2 stages. 1) Decision of technology; 2) Demand for water reuse	W_R) 0.48*
2012-Feres	Brazil, P. S. river basin	2 stages. 1) Decision of technology; 2) 2 water demand eq.: a) reuses water, b) no reuses water	a)-4.82/-1.82 b)-2.69/-0.49
2012-Ku	South Korea	Total production	-1.44/3.97**

Methodology

Production function (Revenue)

$$Q_k = g(Z_k, F_{1k}, \dots, F_{ik}, \dots, F_{vk})$$

Benefit=Revenue -Costs

Optimal condition

$$\rho_{F_i k} = \frac{\partial Q_k}{\partial F_i} = P_{F_i}$$

Shadow price

Trans-Log production function

$$\ln Q = h(Z, F_1, \dots, F_i, \dots, F_v) = Z + \sum_{i=1}^{v} \beta_i \ln F_i + \sum_{i=1}^{v} \delta_i (\ln F_i)^2 + \sum_{i=1}^{v} \sum_{\substack{j=1 \\ j \neq i}}^{v} \varepsilon_{ij} (\ln F_i)(\ln F_j)$$

Methodology

Product-input Elasticity

$$\sigma_{F_i} = \frac{\partial \ln Q}{\partial \ln F_i} = \beta_i + 2\delta_i \ln F_i + \sum_{\substack{j=1 \\ i \neq j}}^{v} \varepsilon_{ij} \ln F_j$$

Productivity

$$\rho_{F_i} = \sigma_{F_i} \frac{Q}{F_i}$$

Direct input-price elasticity

$$\gamma_{F_i F_i} = \frac{\partial \ln F_i}{\partial \ln P_{F_i}} = \frac{\sigma_{F_i}}{2\delta_i + \sigma_{F_i}{}^2 - \sigma_{F_i}}$$

Cross-price input elasticity

$$\gamma_{F_i F_j} = \frac{\partial \ln F_i}{\partial \ln P_{F_j}} = \frac{\sigma_{F_j}}{\varepsilon_{ij} + \sigma_{F_i} \cdot \sigma_{F_j}}$$

Data

- **National Survey of Industrial activity (ENIA)**
- **CIIU**
- **Panel 1995 -2006 (12 years)**
- **51,449 observations**

Variable	*Mean*	*SD*	*Min*	*Max*
Q (thousands of $)	*2,940,524*	*2.5E+07*	*1469*	*2.2E+9*
W (quantity of m^3)	*28,542*	*4.4E+05*	*1*	*3.6E+7*
Cost of W (thousands of $)	*8,040*	*2.0E+05*	*0*	*2.5E+7*
K (thousands of $)	*1,961,823*	*3.0E+07*	*0.7*	*4.0E+9*
L (number of people)	*74*	*158.2*	*1*	*4,432*
Cost of L (thousands of $)	*283,265*	*9.7E+05*	*0*	*4.1E+7*
E (thousands of $)	*97,467*	*1.1E+06*	*0.7*	*1.1E+8*
M (thousands of $)	*2,182,848*	*1.9E+07*	*0.1*	*9.5E+8*
Property (1: foreign)	*10%*	*0.3*	*0*	*1*
Firm size (1: L>=150)	*11%*	*0.3*	*0*	*1*
Dummies for year, CIIU clasification , region				

Results and discussion

Elasticities and productivities

	W	K	L	E	M
σ	0.0172	0.0483	0.2959	0.0600	0.6160
ρ (thousands of CL$ 1995/m^3)	1.7751	0.0724	11,764	1.8117	0.8298
γ_W	−1.3191	40.600	26.820	−94.416	156.16
γ_K	14.488	−1.3933	9.2314	12.631	59.754
γ_L	1.5615	1.5061	−2.8606	21.006	7.8053
γ_E	−27.090	10.156	103.52	−6.2767	−111.40
γ_M	4.3678	4.6837	3.7499	−10.860	−6.8482

Elasticities and productivities by sector

Measure	σ_W	ρ_W (thousands of CL$ 1995/m3)	γ_{WW}	Mean cost (thousands of CL$ 1995/m3)
General	**0.0172**	**1.7751**	**–1.3191**	**5.1031**
151	**0.0239**	**2.4617**	**–1.2284**	**5.0066**
152–155	**0.0169**	**1.7453**	**–1.3253**	**5.4462**
153	**0.0173**	**1.7805**	**–1.3180**	**4.8477**
154	**0.0115**	**1.1799**	**–1.5372**	**5.3560**
17	**0.0066**	**0.365**	**–2.4708**	**4.7834**
18	**0.0088**	**0.9018**	**–1.8216**	**4.9413**
19	**0.0127**	**1.3093**	**–1.4648**	**4.9995**
20	**0.0335**	**3.4531**	**–1.1751**	**4.4589**
21	**0.025**	**2.5769**	**–1.2192**	**4.8664**
22	**0.0109**	**1.1225**	**–1.5778**	**4.9031**
24	**0.0305**	**3.1443**	**–1.1867**	**5.4496**
25	**0.015**	**1.5408**	**–1.3770**	**5.0594**
26	**0.0176**	**1.8124**	**–1.3117**	**5.0065**
27	**0.0425**	**4.3747**	**–1.1542**	**4.9229**
28	**0.0235**	**2.4163**	**–1.2323**	**5.5530**
29	**0.0222**	**2.2892**	**–1.2445**	**5.0435**
31–32–33	**0.0183**	**1.8811**	**–1.2992**	**4.9824**
34–35	**0.0177**	**1.8262**	**–1.3091**	**5.5286**
36	**0.0072**	**0.4264**	**–2.2075**	**4.9000**

CONCLUSIONS

- Input elasticity was estimated as -1.32 (-2.47 “textile” / -1.15 “metals”)
- Implicit price of water was of 1,775 CL$/m3 of 1995 (US$3).
- We found substitution for inputs except for Energy and water and Intermediate material and energy.
- The sector “commons metals” are the most intensive in water use, lower elasticity and high value.