Estimating Spillover Effects of Technology Development Funds (TDF): The case of FONTAR

Victoria Castillo (MTESS Argentina) Alessandro Maffioli (IDB) Sofia Rojo (MTESS Argentina) Rodolfo Stucchi (IDB)

Outline of the presentation

- ❑   Motivation

- ❑   Literature

- ❑   The program

- ❑   Data

- ❑   Identification strategy

- ❑   Preliminary results

Motivation

❑ In LAC, an increasing number of studies has shown evidence of positive direct effects of Technology Development Funds (TDF) on R&D investment and performances (Hall and Maffioli, 2008; Castillo et al. 2011; Crespi, Maffioli and Melendez, 2011; Crespi, Solis and Tacsir, 2011)

❑ In the specific case of FONTAR, previous evaluations found direct effects of the program on R&D investment, but not on performances (Binelli and Maffioli, 2007 and Chudnovsky et al. 2008).

❑ These studies left two key questions unanswered: (i) what are the long run effect of the TDF (FONTAR) on firms performances? (ii) what are the spillover effects of TDF ?

❑ Our study tackle both questions:

(i) Long run effects of the FONTAR program on firm performance measured in terms of growth (employment), real wages, and the probability of exporting;

(ii) Long run spillover effects on firms that did not benefit from the program directly.

Literature

❑ Most of the literature addressing the effectiveness of TDF or R&D subsidies or other innovation support instruments focused on the effect on innovation activities.

▪ **Participation in R&D projects has been identified as a crucial factor for alleviating barriers to cooperation** (Eom and Lee, 2010), affecting the probability of setting up an R&D partnership with research or technological organizations or other firms (Falk, 2007; Busom and Fernandez-Ribas, 2008), expanding the industry-university-government network (Nishimura and Okamuro, 2011) or increasing participation in new research joint ventures (Feldman and Kelley, 2006).

▪ **Absence of a full "crowding-out" between public and private spending on R&D** (Aerts and Schmidt, 2008; Gonzalez and Pazo, 2008; Czarnitzki and Lopes-Bento, 2012).

▪ **R&D public programs have been found to have a positive impact on the development of new production processes and products** (Cappelen et al., 2011; Czarnitzki et al., 2011), and **increase R&D jobs** (Czarnitzki and Lopes-Bento, 2012) **and R&D wages** (Wolff and Reinthaler, 2008).

▪ **Positive results of TDF programs on employment generation** (Hall and Maffioli, 2008; Lopez Acevedo and Tan, 2010).

IDB.✓
Development Effectiveness

Literature

- ❑ Vast literature on the knowledge spillover among firms. In particular, the labor mobility channel for spillovers has been highlighted both in theoretical models and in the empirical literature:

- ▪ **Trade-related and foreign direct investment (FDI)-related knowledge spillovers** include works by Aitken and Harrison (1999), Motta and Ronde (2001), Glass and Saggi (2002), Schulz (2003), Gorg and Greenaway (2004), Gorg and Strobl (2005), Martins (2006), Wei and Liu (2006), Buckley et al. (2007), Monteiro et al. (2008), Liu et al. (2009), Ragnhild (2011).

- ▪ More specifically the **mobility of skilled individuals** is identified as a crucial factor behind knowledge transfer and the productivity of firms and regions → Intra-firm and inter-firm human mobility as a channel of knowledge transfer and dissemination of embodied tacit knowledge within a country: Jaffe et al. (1993), Saxenian (1994), Almeida and Kogut (1999), Lawson (1999), Maskell and Malmberg (1999), Cooper (2001), Fosfuri et al. (2001), Glass and Saggi (2002), Gertler (2003), Almeida and Phene (2004), Fosfuri and Ronde (2004), Power and Lubdmark (2004), Hudson (2005), Rodriguez-Pose and Vilalta-Bufi (2005), Boschma, Eriksson and Lindgren (2009).

- ❑ Almost nothing has been done on estimating spillover effects of PDP. A parallel study on Cluster Development Policies in Brazil consider spillover by geographical proximity (Figal Garone et al. 2012).

IDB.✓
Development Effectiveness

The FONTAR program

❑ The Argentinean Technological Fund (*Fondo Tecnologico Argentino* – FONTAR) has been one of the pillars of Argentina's innovation policy. The program includes three main funding mechanisms:

1. **Matching grants** (since 2000): the ANRs target innovation projects with higher risk and less tangible assets. They finance up to 50% of eligible expenses, up to a maximum of AR$ 850,000 (US$ 195,000). Mostly for SMEs.

2. **Credit**: the CAEs target technological modernization projects with relatively lower risk and higher tangible assets. They finance up to 80% of eligible expenses, up to a maximum of AR$ 2,000,000 (US$ 460,000). For large and SMEs.

3. **Tax credit**: the CF target both innovation and technological modernization projects. They finance up to 50% of eligible expenses, up to a maximum of AR$ 3,000,000 (US$ 690,000). For large and SMEs.

4. Recently **Cluster and Provider Development** mechanisms have been introduced. The FITs target both innovation and technological modernization projects. They finance up to 80% (or 50%) of eligible expenses, up to a maximum of AR$ 16,000,000 (US$ 3,700,000). For large and SMEs.

The program

	R&D	Tecnological modernization	Investment

Characteristics

Risk

Intangibles ➝ Tangibles

Eligible activities

R&D	Tecnological modernization	Investment
Product development	**Purchase of high-tech Equipment**	**Industrial plant**
Product innovation	**Automatization**	**Purchase of equipment for the new plant**
Process innovation	**Management and quality control technologies**	**Production scaling up**
Applied research		
Pilot plant	**Vertical integration**	
MATCHING GRANTS	CREDIT	✗

Source: FONTAR, http://www.agencia.gov.ar

Analytical Framework

❑ Our data allow us to evaluate both direct and indirect effects of the program on employment, wages, and exports. All these are important outcomes, but we are still missing one key expected result of a TDF: productivity.

❑ Can we infer something from our data on firms' productivity?

❑ If we observe a joint increase in employment and wages, these increases could come from:

  ▪ An improvement in productivity.

  ▪ An increase in the capital labor ratio.

❑ There are several papers addressing the relationship between productivity and exports. Most of them find that most productive firms are the ones that are able to enter in the export market (Selection hypothesis of international trade).

Two type of beneficiaries

Direct Beneficiaries:

Treated firms, i.e., firms that applied and received support from the program.

Spillovers through mobility of high skilled workers

Indirect Beneficiaries:

Non-treated firms that hired workers that were working in a treated-firm.

IDB.✓
Development Effectiveness

Data for the evaluation

❑ Two sources of data:

    ❑ Administrative data from the FONTAR program.

    ❑ Administrative data of the Social Security System and Customs adapted and managed by OEDE.

❑ Employer-Employee Panel Data with the whole population of (formal) firms and workers after 1996.

❑ Through a specific routine we can track mobility of workers across firms.

❑ Employee data: wage, time in the current job, gender, age.

❑ Firm level data: sector, location, employment, wages, exports, age of the firm (experience of the firm), average number of years that workers have in the firm (experience of workers).

FONTAR's direct beneficiaries

Entered the market	Entered FONTAR											
	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
1994	40	8	10	56	67	45	60	22	64	118	58	13
1995	1			3	1	5	4		4	13	8	1
1996					5	4	3	4	6	9	6	1
1997				3	1	4	9	1	6	15	3	1
1998				6	1		3		4	12	9	
1999						1	6	4	10	10	5	1
2000							7	1	5	22	4	1
2001							6	1	6	11	6	2
2002								1	2	12	6	4
2003									7	23	5	5
2004											5	5
2005											1	2
2006												1

359 direct beneficiaries
(cohort that entered the program in 2003 and 2004)

271 of them were active since 2000
(these are the firms we consider because our identification strategy requires knowing ex-ante trend in outcome variables)

IDB.
Development Effectiveness

The mobility of beneficiaries' workers

❑ 121,924 employees worked in a FONTAR beneficiary firm between 1995 and 2006.

❑ There is enough mobility (even too much!) to consider spillovers by mobility of workers.

	Years in a FONTAR firm					
	Less than 1	1 a 3	4 a 5	5 a 10	More than 10	Total
Move to other firm	41,896	15,201	4,627	1,834	23	63,581
Stay in the firm	16,533	14,457	13,250	12,335	1,768	58,343
Total	58,429	29,658	17,877	14,169	1,791	121,924

❑ 63,581 workers that were in a FONTAR firm generated more than 117,000 transitions (they moved more than once).

IDB.✓
Development Effectiveness

Who is an indirect beneficiary?

❑   We need a rule to define who are the indirect beneficiaries. The mobility is too high and we do not expect spillovers from every transition (plus other problems such as change of CUIT).

❑   High turn-over might reflect low skills. Firms aim at having high skilled workers for long periods.

❑   To restrict the definition of mobility we have several alternatives. We consider two:

   ❑   Workers remained at **least two years** in the origin-firm after the firm entered the program (i.e. they learned something from the FONTAR project).

   ❑   Workers were in the **top quintile of the origin-firm wage** distribution

Therefore, Indirect beneficiaries are those firms that:
1.   Did not participate in FONTAR.
2.   Hired skilled employees (top quintile in the firm wage distribution) that were working in a firm that received FONTAR in 2003 or 2004 (cohort of interest).
3.   They hire these workers in 2006 or 2007 (we focus on a cohort).

❑   We end up with **370 indirect beneficiary** firms (based on a cohort of **271 direct beneficiaries**).

IDB
Development Effectiveness

Empirical Strategy

❑ Participation in the program was not random. Firms self-selected into the program and into the type of support they wanted.

❑ We use the panel structure of the data set to exploit between and within-firm variability to estimate the impact. Assuming unobserved heterogeneity constant over time, selection bias can be mitigated using a fixed effects model.

❑ To make the basic assumption of our identification strategy more credible, we use propensity score matching to find firms with similar characteristics in:

  ❑ Direct beneficiaries: 2003 (we assume no impact in the first year)

  ❑ Indirect beneficiaries: 2006 (we assume no impact in the first year)

❑ Include ex-ante trend in outcome variables (3 years before the baseline for each cohort)

IDB.✓
Development Effectiveness

Empirical Strategy

We estimate the following equation with fixed effects:

$$y_{it} = d \, T_{j,i,t-1} + a_j \, x_{it} + m_t + m_i + e_{j,it}, \quad i \text{ in } CS_j, \; j=(D,I) \qquad (1)$$

❑ $T_{j,i,t}$ takes value 1 after firm i receives support j *(D=direct, I=indirect)*; x_{it} are control variables; m_t are year dummies to capture time varying non-observable factors affecting all firms (in a second specification interacted with industry dummies); m_i captures time invariant non-observed firm characteristics affecting participation and outcomes.

❑   the identification assumption (time-constant unobserved heterogeneity) is less likely if treated and untreated firms are very heterogeneous → may differ in unobserved time varying factors.

❑   to mitigate this bias, we run regressions (1) on a common support of firms with similar ex-ante characteristics, including ex-ante trend of the outcome variable.

IDB.✓
Development Effectiveness

Findings

	Employment	Wage	Prob. of exporting
(A) Direct impact			
Average impact	22.4%	3.5% (NS)	7.2%
Dynamic impact	Impact after one year and significant after 7 years	Impact after three years and significant after 7 years	Impact after one year and significant after 7 years
(B) Indirect impact (spillovers)			
Average impact	16.5%	2.5% (NS)	1.6% (NS)
Dynamic impact	Impact after one year and significant after 3 years	Impact after 3 years	Impact after 2 years

Findings (Direct effects)
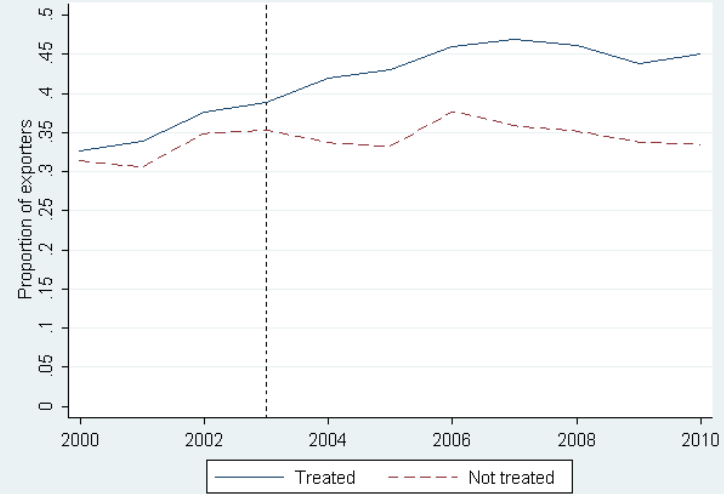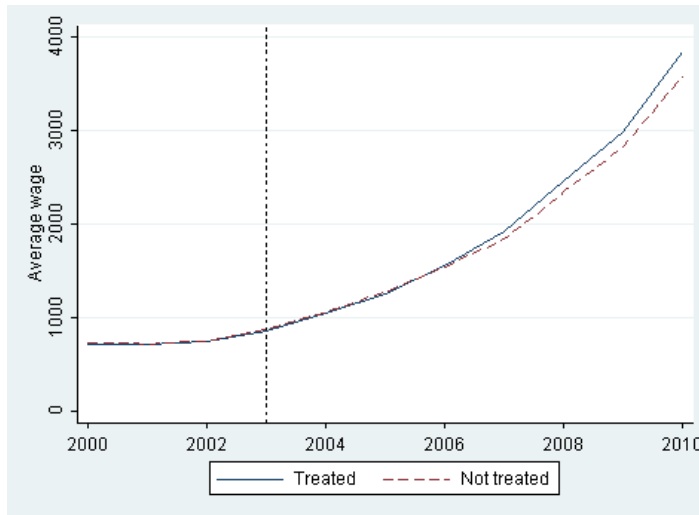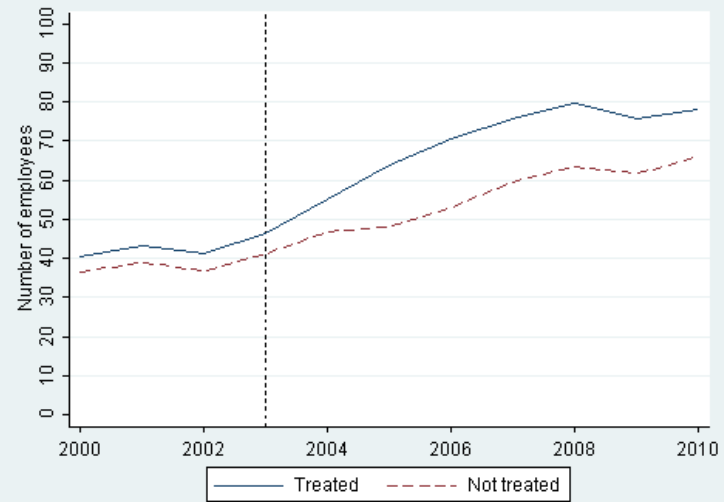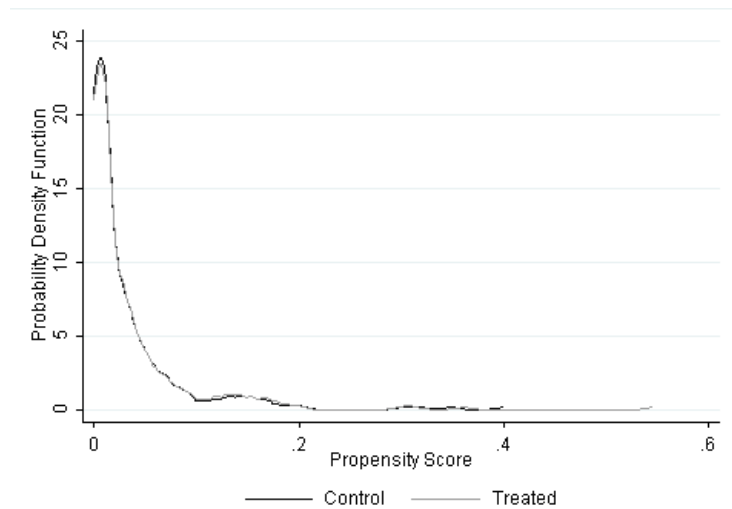
Findings (Indirect effects)
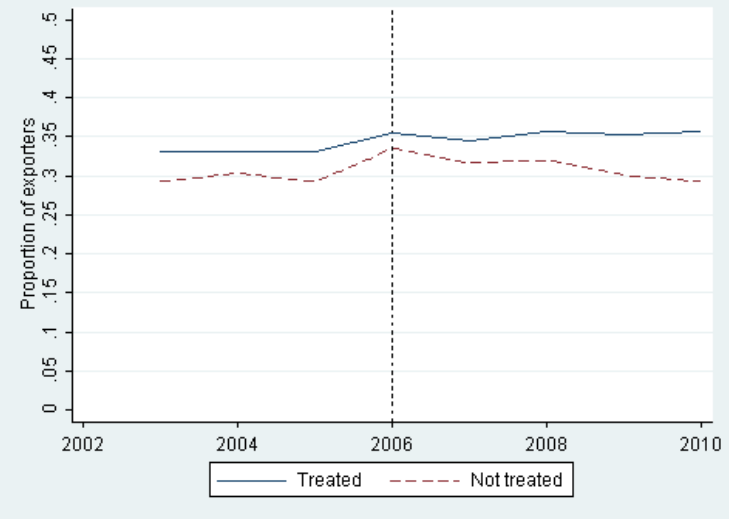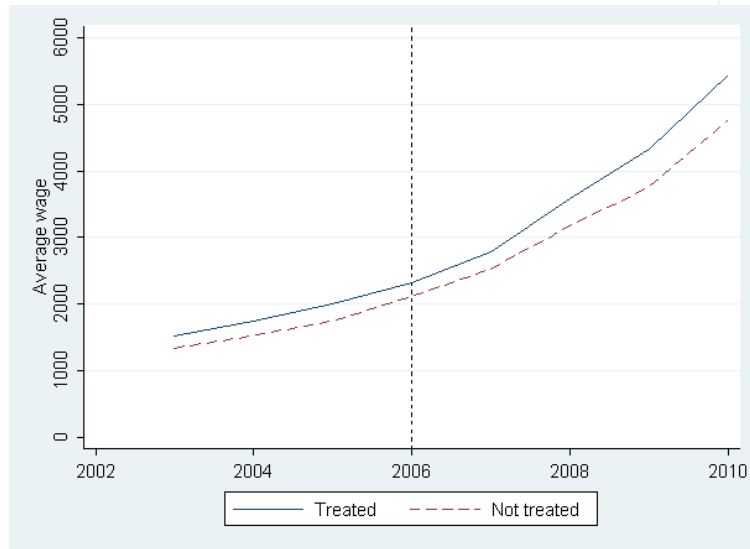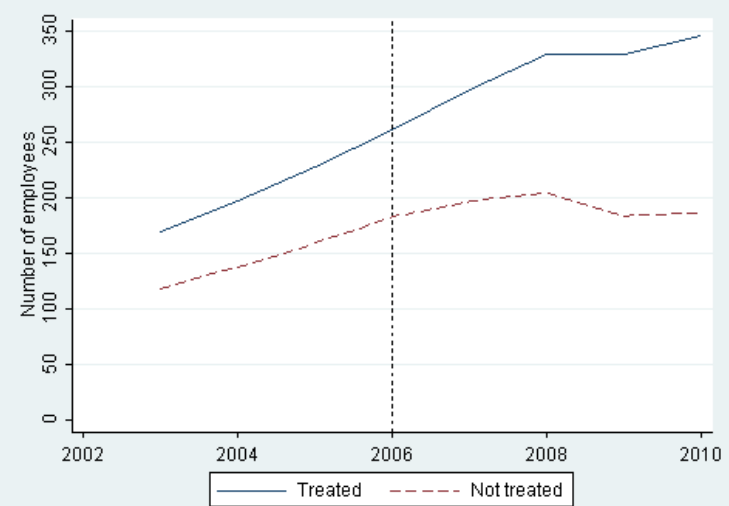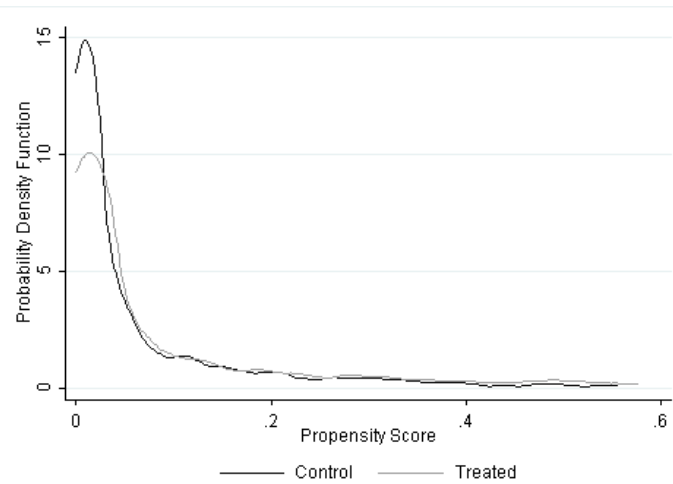
Thank you

Balance: Direct effect	Unmatched			Matched		
	Treated	Control	Statistical significance of the difference	Treated	Control	Statistical significance of the difference
Firm's age 03 (log)	2.3	2.1	***	2.3	2.3	
Employment 00	35.7	5.8	***	35.7	33.0	
Employment 01	38.1	6.1	***	38.1	36.6	
Employment 02	36.7	5.9	***	36.7	35.1	
Employment 03	41.8	6.3	***	41.8	40.2	
↑ Employment 00	21.0	3.4	***	21.0	20.0	
↑ Employment 01	19.6	3.3	***	19.6	17.9	
↑ Employment 02	17.6	2.7	***	17.6	14.7	
↑ Employment 03	25.5	3.5	***	25.5	23.8	
↓ Employment 00	17.8	3.0	***	17.8	16.7	
↓ Employment 01	19.0	3.3	***	19.0	17.9	
↓ Employment 02	18.2	2.6	***	18.2	14.4	
↓ Employment 03	17.9	3.1	***	17.9	15.6	
Average wage 00	635.8	413.1	***	635.8	637.0	
Average wage 01	677.1	443.3	***	677.1	665.3	
Average wage 02	731.3	489.9	***	731.3	724.1	
Average wage 03	857.2	611.8	***	857.2	867.0	
New workers' wage 00	472.9	199.9	***	472.9	466.6	
New workers' wage 01	467.4	197.8	***	467.4	431.5	
New workers' wage 02	484.2	201.1	***	484.2	466.8	
New workers' wage 03	557.6	244.3	***	557.6	566.1	
Mean of unionized workers 00	80.6	81.3		80.6	74.7	**
Mean of unionized workers 01	84.9	88.5	**	84.9	80.6	*
Mean of unionized workers 02	87.7	94.8	***	87.7	86.1	
Mean of unionized workers 03	89.1	98.2	***	89.1	87.3	
Exports value 00	560,000	21,468	***	560,000	1,300,000	
Exports value 01	750,000	20,153	***	750,000	1,800,000	
Exports value 02	660,000	17,265	***	660,000	2,100,000	
Exports value 03	730,000	20,285	***	730,000	2,300,000	**Return**
Region X Industry	Significant differences			No significant differences		
Size X Industry	Significant differences			No significant differences		

Balance: Indirect effect

	Unmatched			Matched		
	Treated	Control	Statistical significance of the difference	Treated	Control	Statistical significance of the difference
Firm's age 06 (log)	2.4	1.9	***	2.4	2.4	
Employment 03	249.2	4.4	***	249.2	226.4	
Employment 04	284.8	5.3	***	284.8	284.4	
Employment 05	331.6	6.2	***	331.6	362.8	
Employment 06	375.2	6.9	***	375.2	441.7	
↑ Employment 03	127.8	2.6	***	127.8	85.6	*
↑ Employment 04	148.6	3.3	***	148.6	146.5	
↑ Employment 05	181.0	4.1	***	181.0	197.3	
↑ Employment 06	211.9	4.1	***	211.9	202.0	
↓ Employment 03	104.3	1.9	***	104.3	53.8	**
↓ Employment 04	107.8	2.5	***	107.8	78.7	
↓ Employment 05	133.5	3.3	***	133.5	105.7	
↓ Employment 06	181.6	3.9	***	181.6	138.0	
Average wage 03	1344.5	422.1	***	1344.5	1277.1	
Average wage 04	1738.5	607.7	***	1738.5	1491.4	
Average wage 05	1910.9	833.7	***	1910.9	1799.5	
Average wage 06	2265.1	1049.2	***	2265.1	2203.4	
New workers' wage 03	1080.1	198.6	***	1080.1	977.8	
New workers' wage 04	1262.1	306.2	***	1262.1	1010.0	
New workers' wage 05	1542.3	426.8	***	1542.3	1552.5	
New workers' wage 06	1784.3	465.0	***	1784.3	1635.9	
Mean of unionized workers 03	69.9	67.3		69.9	71.5	
Mean of unionized workers 04	73.9	81.9	***	73.9	75.1	
Mean of unionized workers 05	79.2	95.3	***	79.2	80.9	
Mean of unionized workers 06	79.4	98.4	***	79.4	81.3	
Exports value 03	11,000,000	12,241	***	11,000,000	5,200,000	
Exports value 04	13,000,000	14,391	***	13,000,000	5,700,000	
Exports value 05	15,000,000	17,418	***	15,000,000	7,200,000	
Exports value 06	17,000,000	19,970	***	17,000,000	8,500,000	
Region X Industry	Significant differences			No significant differences		
Size X Industry	Significant differences			No significant differences		

Return