University of Trento
PhD Program in Economics & Management

Title:

Public R&D Policy Impact Evaluation: Propensity Score Matching and Structural Modelling Estimations

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Why innovation policy ?

- ***Innovative activity and economic growth***
  - Schumpeter's process of creative destruction: Endogenous growth theory
  - Accumulation of knowledge as the source for sustained economic growth
    - Romer (1986) and Lucas (1988)
  - Semi-endogenous growth (Jones, 1995) : Population as the factor influencing economic (long-run)
  - Fully-endogenous growth (Peretto, 1998): Innovation (R&D) intensity and population
- ***Innovation (R&D) spillovers***
  - Diffusion and adoption of the new technology
  - Same industry (vertical) vs. cross sector (horizontal)
- ***Market failure and the need for public R&D policy and intervention***
  - Lack of appropriability (due to copy and imitation) and the presence of knowledge spillovers
  - Risk and uncertainty
  - Firms' underinvestment in R&D

Public R&D policy

- ***Different types of R&D policies***
  - IPR: Patents
  - R&D Award (Prizing): conservative award estimation, the need to transfer the knowledge
  - Procurement contracts or contractual mechanism: mostly used for defense and space projects
  - Tax Credits: more market-oriented policy, quicker effect than direct grants
  - Incentives for collaborative R&D: university-industry relationship (knowledge exploiting vs. knowledge producing), RJVs
  - Direct R&D Subsidies
- *The main question for policy makers is whether the adopted innovation policy promotes a firm to undertake an R&D project or to invest additionally in existing R&D project(s) that the firm would not have undertaken without the intervention (Jaffe, 2002) : If public R&D spending is a complementarity (crowd- in) or is a substitute (crowd out) private R&D spending ?*

Innovation (R&D) activity and R&D policy in practice

- ***The gross domestic expenditure on R&D (GERD%) and Business enterprise expenditure on R&D (BERD%)***
- ***EU Level: R&D and European perspective (Lisbon Strategy 2000-2010 and Europe Horizon 2020)***
  - the goal of a 3 % of R&D expenditure as a percentage of gross domestic production (GDP)
  - R&D expenditure in the EU-28 countries accounted for 2.03% of the EU GDP by 2015
  - Sweden (3.26%), Austria (3.07%) and Denmark (3.03%) are the only countries performed above the 3 percent ratio in 2015
  - Finland has decreased the amount of GERD% from 3.75% in 2009 (as the highest amount ever recorded) to 2.9% in 2015
  - Italy (1.33%) less than Ireland(1.5%) and Estonia (1.5%) and higher than Luxembourg (1.31%), Portugal (1.28%) and Spain (1.22%).
  - Italy's 2020 target of 1.53% is not out of reach
- ***Italy : Diversified regions***
  - Trento : 0.6% in 2001, 1.1% in 2005, 2.1% in 2009, 1.71% in 2012
  - In 2009 the highest in Italy more than Piedmont (Piemonte) and Lazio

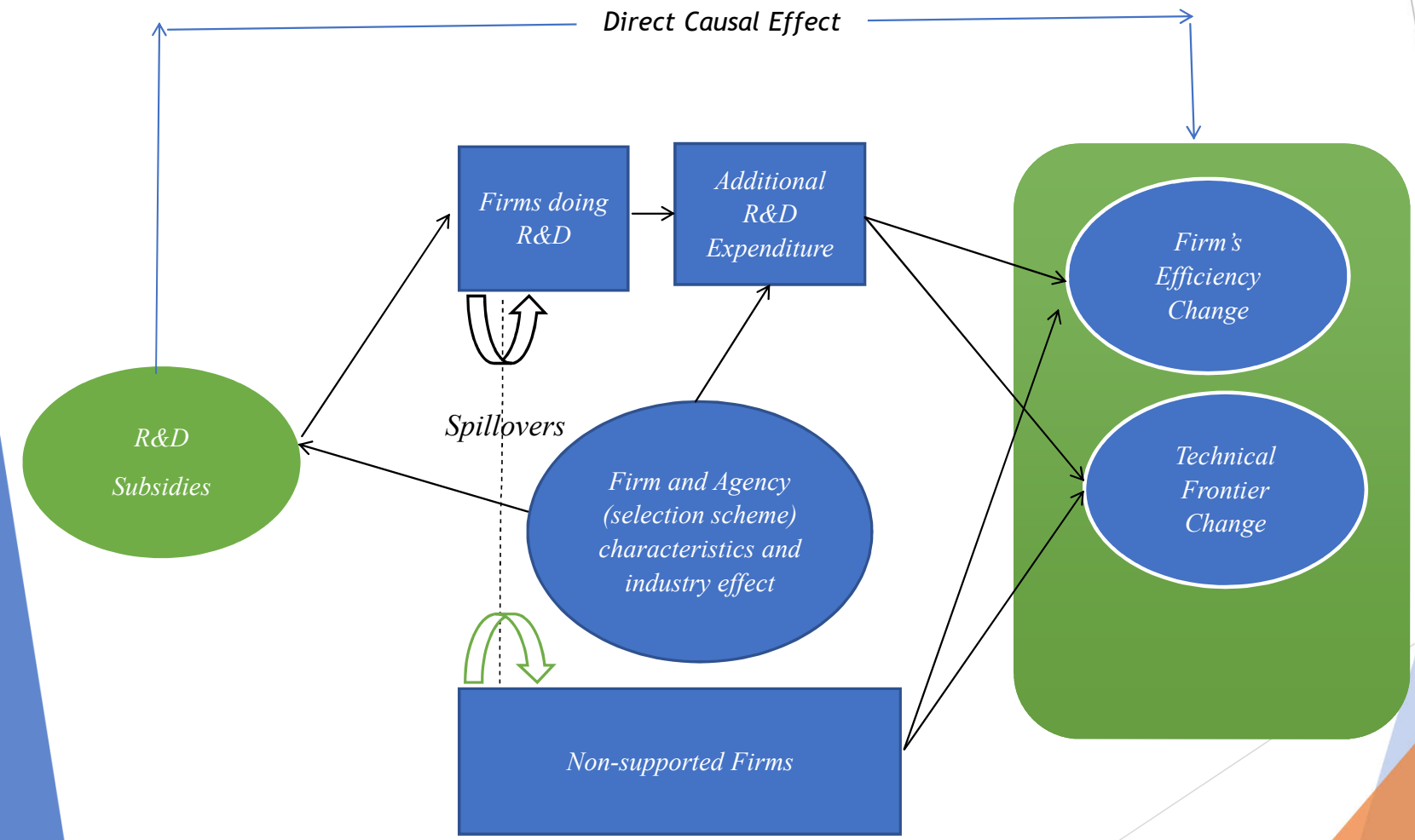
R&D policy evaluation

- ***Challenges***
  - Selection bias and endogeneity problem
  - Multiple treatment : Co-presence of incentives
  - Time span: Short-term vs. long-run effects
  - Mixed heterogenous findings and lack of conclusiveness

Literature review: R&D policy evaluation

- ***Taxonomies: David, Hall and Toole (2000), Griliches (2008)***
- ***Literature related to the impact of R&D subsidies on input, output and behavioral additionality***
  - Input additionality: Clausen (2009), Bronzini & Iachini (2014), Marino et al. (2016)
  - Output additionality: Czarnitzki & Licht (2006), Bronzini & Piselli (2016)
  - Behavioral additionality: Autio et al. (2008), Hsu et al. (2009)
- ***Literature related to the impact of R&D subsidies on other outcome variables***
  - Total factor productivity (TFP): (Colombo et al., 2011; De Jorge & Suarze, 2011; Howell, 2017)
  - Technology adoption (Atzeni & Carboni, 2008)
  - Spillovers effect (Takalo et al., 2013)
  - Internationalization (FDI) and performance in terms of turnover (Bann`o et al., 2014)
  - Innovative productivity (Howell, 2014; Zhao & Ziedonis, 2014)
  - Employment, capital investment and turn over (Cerqua & Pellegrini, 2014)
  - Survival (Howell, 2014; Zhao & Ziedonis, 2014; Wang et al., 2015)
  - Patenting and new investment (Wang et al., 2015)

Conceptual framework for impact evaluation



Research Hypotheses (Thesis Chapter 3)

- *H.1: Public R&D subsidies affect (positively/negatively) total factor productivity (TFP) growth.*
  - *H1.1: Public R&D subsidies affect (positively/ negatively) technical efficiency change (EFFCH).*
  - *H1.2: Public R&D subsidies affect (positively/ negatively) technological frontier progress (technological efficiency (TECHCH).*
- *H.2: R&D subsidies allocation schemes influence on the impact of the R&D subsidies on TFP and its components (technical efficiency and technological change).*
- *H.3: The industry and sector the firm performs in, has an effect on the impact of R&D subsidies on TFP change and its components.*
- *H.4: The impact of public R&D subsidies on TFP change is time invariant. (Or: The effect of the R&D subsidies on TFP growth is different in the short term and long run.*

- The effect of observable factors and assuming SUTVA (Stable Unit Treatment Value Assumption)

Research Hypotheses (Thesis Chapter 4)

- The R&D incentive program in our context consists of different stages:
  - participation and application decision (self-selection stage)
  - Evaluation and subsidy rate decision (selection stage)
  - Private firm R&D expenditure (investment decision)

- *H.5: R&D subsidies affect additional R&D expenditure.*
- *H.6:[Which] Firm characteristics influence on R&D investment.*
- *H.7:[Which] Firm characteristics influence on R&D subsidies rate.*
- *H.8:[Which] Firm characteristics influence on R&D application decision.*

- Concerning the effect of unobservable factors and taking into account the spillovers effect

Place-based R&D Subsidy Program and Institutional Context : LP6/99, Trento, Italy

- Law LP. 6/99 to support applied research projects at the firm level
- APIAE (Provincial Agency for the promotion of economic activities: Agenzia Provinciale per l'Incentivazione delle Attività Economiche): Incentives given to firms operating in Province of Trento for research and development expenditures
- Evaluation: automatic (SMEs), evaluative (two stage), negotiating

Thesis Chapter 3: Measuring the effect of place-based R&D subsidies on TFP change and its components

- ***Models and methodologies to measure productivity***
- ***Methodology to measure the treatment (R&D subsidy) effect***

Models and methodologies to measure productivity

- Data Envelopment Analysis (DEA) Approach: Non-parametric linear programming model first introduced by Charnes, Cooper and Rhodes (CCR) in 1978
- DEA CRS Output-Oriented dual model

$$Max\ \theta$$

$$s.t.$$

$$\sum_i \lambda_i x_{ji} \leq x_{jn}\ \forall\, j$$

$$\sum_i \lambda_i x_{ji}\ \geq \theta y_{kn} \forall\, k$$

$$\lambda_i \geq 0\ \ \forall i$$

Methodologies to measure TFP change (technical efficiency and technological frontier changes)

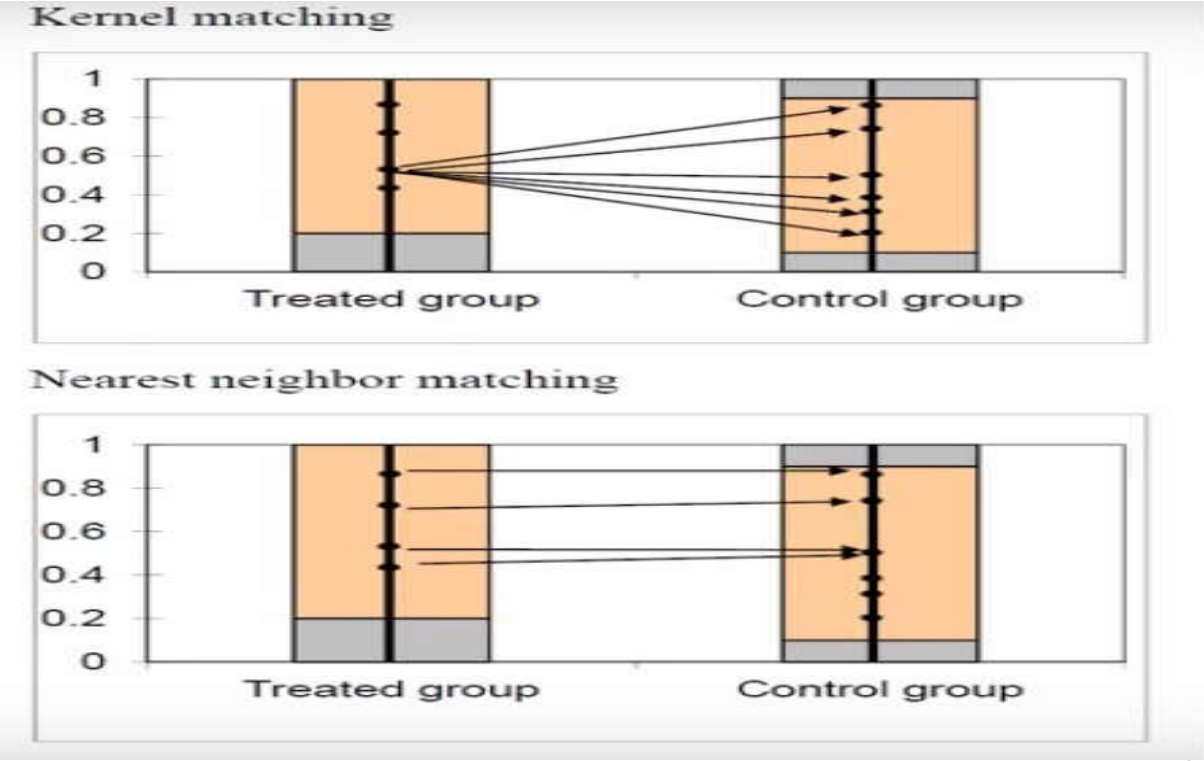
- DEA using input and output data of each decision making unit (DMU)shapes the efficiency frontier and measures the distance of DMU from the frontier to measure the technical (in)efficiency
- The frontier and the distance to frontier captured through time intervals to estimate efficiency change and technical frontier change
- The method used is DEA-based Malmquist Productivity Index (MPI) approach first introduced by Caves, Christensen and Diewert (CCD:1982) based on calculation of distance function measures
- $M_0(y_{t+1}, x_{t+1}, y_t, x_t) = \frac{d_0^{t+1}(x_{t+1},y_{t+1})}{d_0^t(x_t,y_t)} \cdot \left[\frac{d_0^t(x_{t+1},y_{t+1})}{d_0^{t+1}(x_{t+1},y_{t+1})} \frac{d_0^t(x_t,y_t)}{d_0^{t+1}(x_t,y_t)}\right]^{1/2}$
- $EFFCH = \frac{d_0^{t+1}(x_{t+1},y_{t+1})}{d_0^t(x_t,y_t)}$
- $TECHCH = \left[\frac{d_0^t(x_{t+1},y_{t+1})}{d_0^{t+1}(x_{t+1},y_{t+1})} \frac{d_0^t(x_t,y_t)}{d_0^{t+1}(x_t,y_t)}\right]^{1/2}$

Models and methodology to measure the treatment (R&D subsidy) effect: Propensity Score Matching (PSM)

- To estimate a binary outcome model which is a probit or logit model for the propensity of observations to be treated based on their characteristic(s) (X)
- Dimensionality problem for X solved by introducing a single measure which is the propensity score
- Propensity scores determines the probability of being treated conditional on X (Rosenbaum and Rubin, 1983; Dehejia and Wahba, 2002)
- The treated and non-treated observations with closest propensity scores are matched with each other to form a counterfactual setting to compare of the effect of the policy
- Different matching methods:
  - The nearest neighbor matching
  - Kernel matching
  - Radius matching
  - Stratification matching
- Balancing property

PSM Methods applied

- Nearest neighbor matching vs. kernel matching:



Treatment (R&D subsidies) effect measurement

- Average treatment effect (ATE)
  - $ATE = E[Y_{1i} - Y_{0i}] = E[Y_{1i}|\, D_i = 1, X] - E[Y_{0i}|D_i = 0, X]$

- Average treatment effect on treated $(ATET)$
  - $ATET = E[Y_{1i} - Y_{0i}|D_i = 1, p(X)] = E[Y_{1i}|\, D_i = 1, p(X)] - E[Y_{0i}|\, D_i = 0, p(X)]$

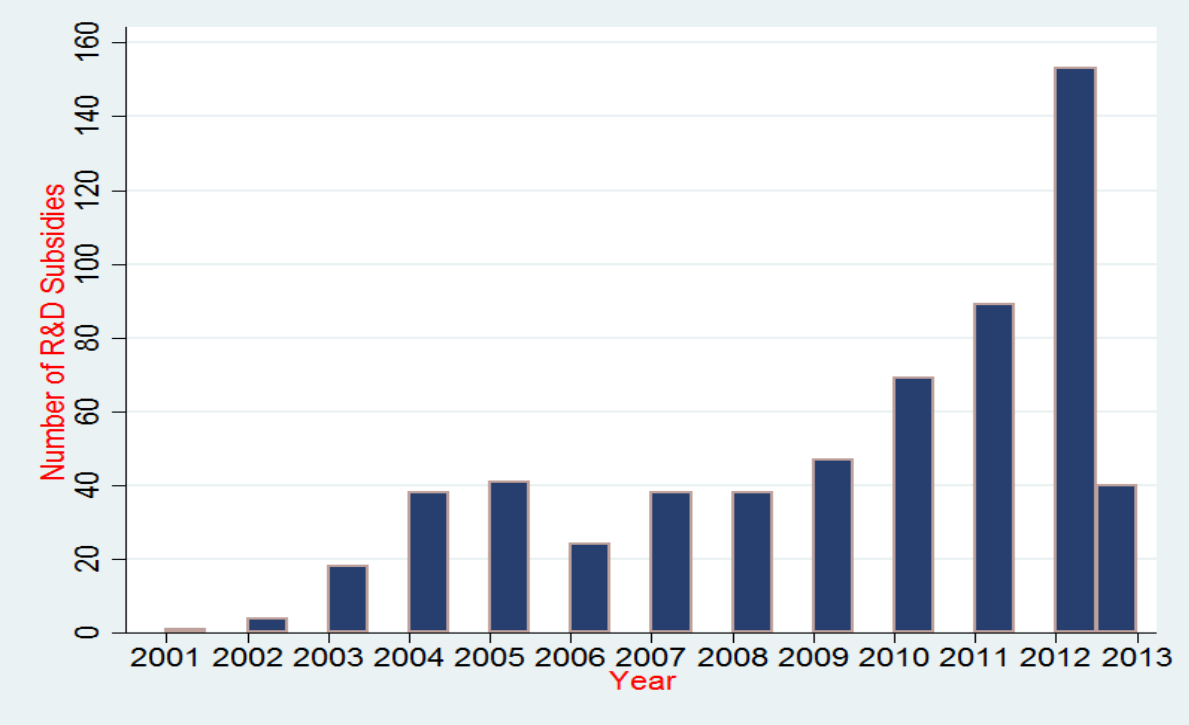
Empirical Strategy

- DEA Malmquist measures will be calculated *within each different sector :* Lee et al. (2011): User-written package for Malmquist measures using Ji and Li (2010) which calculates DEA measures
- Input variables (x_i)
  - Number of employees (the proxy for labour)
  - Moving average of tangible fixed-assets (the proxy for capital stock and capital)
  - Intermediate inputs (the proxy for other factors contributing in production)
- Output variables (y_r)
  - Total revenue

Empirical Strategy

- Data of inputs/output for 7 consecutive years from AIDA (Italian company information and business intelligence) database
- Data on R&D subsides for 2001-2013 is extracted from APIAE's dataset provided by ISPAT office
- The common time interval of data availability for both subsidies and TFP measures will be between 2007-2013
- Final time interval: balanced panel dataset for time interval 2009-2013 (5 years) for total 593 firms
- X_is are the observable factors influencing the selection procedure: *Size, age of the firm and the sector* are the factors chosen as the controls.

Data and Variables related to place-based R&D subsidies



Number of subsidies allocated to projects each year (2001-2013)

Data and Variables related to place-based R&D subsidies

Descriptive statistics for R&D expenditures (Investment by firms and public subsidies)

R&D Expenditure	Mean	Standard Deviation	Min	Max
Total Planned	1,210,163.59	1,662,327.60	36,744.33	16,260,000.00
Actual Accepted Amount	1,049,607.50	1,507,223.33	0.00	16,210,000.00
Public Contribution	583,025.06	966,564.26	0.00	12,035,000.00

Source: Elaboration on APIAE data (All numbers are in Euro €)

The number of subsidy allocations based on the evaluation method by the public agency

Type of Evaluation	***Categories***	***Number of subsidies assigned by each evaluation type***	***Share of total subsidies***
Automatic	*AUTOMATICA*	*127*	
	BANDO 1/2008 – RIC	*44*	
	BANDO 5/2009 – RIC	*32*	
	BANDO 6/2009 – RIC	*22*	
	BANDO 2/2010 – RIC	*37*	
	BANDO 2/2011 – RIC	*15*	
	Total	*277*	*46%*
Evaluative	*VALUTATIVA*	*284*	
	RICERC VALUTATIVA	*3*	
	VALUTATIVA CONGIUNTA	*8*	
	VALUTATIVA con DEROGA	*16*	
	Total	*301*	*50%*
Negotiation	*NEGOZIALE*	*7*	
	NEGOZIALE CONGIUNTA	*5*	
	Total	*12*	*4%*
All Methods	*Total*	*600*	*!00%*

Descriptive statistics of variables used in Malmquist DEA model and other variables of interest

	Subsidized				Non-Subsidized			
Variable	Mean/Median	Std. Dev.	Min	Max	Mean/Median	Std. Dev.	Min	Max
Number of Employees	149	212.25	3	1212	46	131.4297	1	5342
Intermediate Inputs*	39338.6	96294.28	77.847	496991.9	12222.58	35752.13	7.068	556953.3
Average Fixed Asset	8272.05	10841.07	0.5405	47429.5	5434.08	45086.81	0.27	1110105
Revenue (Sales)	49369.01	110535.7	106.346	598582.7	15124.14	41271.55	2.041	676495.2
Age	23.90	15.76	2	64	31.7514	31.19961	1	208
Number of Recorded Subsidiaries	5	6.090486	0	19	2	3.14425	0	31
Number of Companies in Corporate Group	15	42.10086	0	352	18	117.6021	0	1486
Number of Directors	9	7.686614	1	39	7	6.615148	1	40
Total Assets$^{\tilde{}}$	46000.51	70968.38	111.322	324900.5	16261.41	62517.23	42.827	1388085
Total Inventory$^{\tilde{}}$	8164.2	20499.06	0	153852	2634.295	7077.453		137995
R&D** Expenditure$^{\tilde{}}$	427.2358	1053.635	0	4734.744	28.0895	244.7339	0	6343.516
Expected R&D Spending$^{\tilde{\tilde{}}}$	1303673	1430202	0	6398674	–	–	–	–
Total Subsidies$^{\tilde{}}$	624093.5	717576.5	0	3000000	0	0	0	0
Observation	111				4040***			

Sector	Total Observations	No. of Firms	Subsidized Obs.	Non-subsidized Obs.
MANUFACTURING	1316	188	71	1245
CONSTRUCTION	700	100	5	695
WHOLESALE AND RETAIL TRADE; REPAIR OF MOTOR VEHICLES AND MOTORCYCLES	1428	204	3	1425
INFORMATION AND COMMUNICATION	364	52	23	341
PROFESSIONAL, SCIENTIFIC AND TECHNICAL ACTIVITY	343	49	9	334
TOTAL	4151	593	111	4040

The frequency of observations (all, subsidized and non-subsidized) based on industry

Descriptive statistics of outcome TFP measures for subsidized and non-subsidized enterprises based on sector of activity

Industry	Subsidized				Control			
	Tfpch	Effch	Techch	Freq.	Tfpch	Effch	Techch	Freq.
MANUFACTURING	1.044 (0.305)	1.004 (0.378)	1.133 (0.335)	65	1.012 (0.243)	1.047 (0.343)	1.033 (0.294)	1063
CONSTRUCTION	1.214 (0.395)	1.287 (0.651)	1.004 (0.166)	4	1.565 (5.493)	1.541 (5.279)	1.112 (0.402)	596
WHOLESALE AND RETAIL TRADE; REPAIR OF MOTOR VEHICLES AND MOTORCYCLES	1.013 (0.0522)	1.029 (0.100)	0.987 (0.059)	3	1.007 (0.106)	1.00 (0.118)	1.008 (0.071)	1221
INFORMATION AND COMMUNICATION	0.988 (0.268)	0.962 (0.288)	1.034 (0.104)	21	1.033 (0.282)	1.012 (0.269)	1.027 (0.123)	291
PROFESSIONAL, SCIENTIFIC AND TECHNICAL ACTIVITY	1.098 (0.259)	0.975 (0.273)	1.239 (0.523)	8	1.828 (12.636)	1.527 (7.614)	1.060 (0.320)	286
TOTAL	1.043 (0.292)	1.005 (0.360)	1.111 (0.313)	101	1.175 (4.298)	1.153 (3.111)	1.040 (0.259)	3457

Propensity Scores

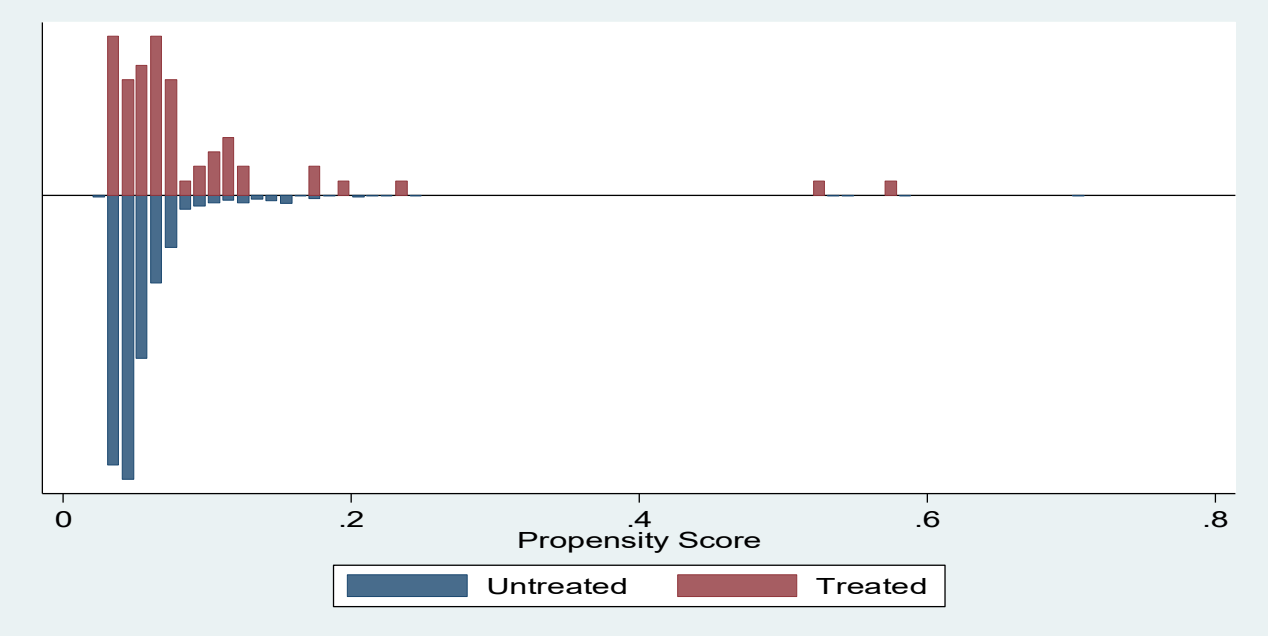
propensity scores by sector of activity

	INDUSTRIES	Subsidized Pscore	Subsidized Freq.	Control Pscore	Control Freq.
Low-medium Tech Industries	MANUFACTURING	0.087*	65	0.0554	1063
		(0.092)**		(0.042)	
	CONSTRUCTION	0.0078	4	0.006	596
		(0.0005)		(0.005)	
	WHOLESALE AND RETAIL TRADE; REPAIR OF MOTOR VEHICLES AND MOTORCYCLES	0.002	3	0.002	1221
		(0.0003)		(0.001)	
High Tech Industries	INFORMATION AND COMMUNICATION	(0.147)	21	0.060	291
		(0.183)		(0.056)	
	PROFESSIONAL, SCIENTIFIC AND TECHNICAL ACTIVITY	0.029	8	0.027	286
		(0.006)		(0.007)	
	TOTAL	0.041	101	0.027	3457
		(0.031)		(0.022)	

* mean **median

Manufacturing sector

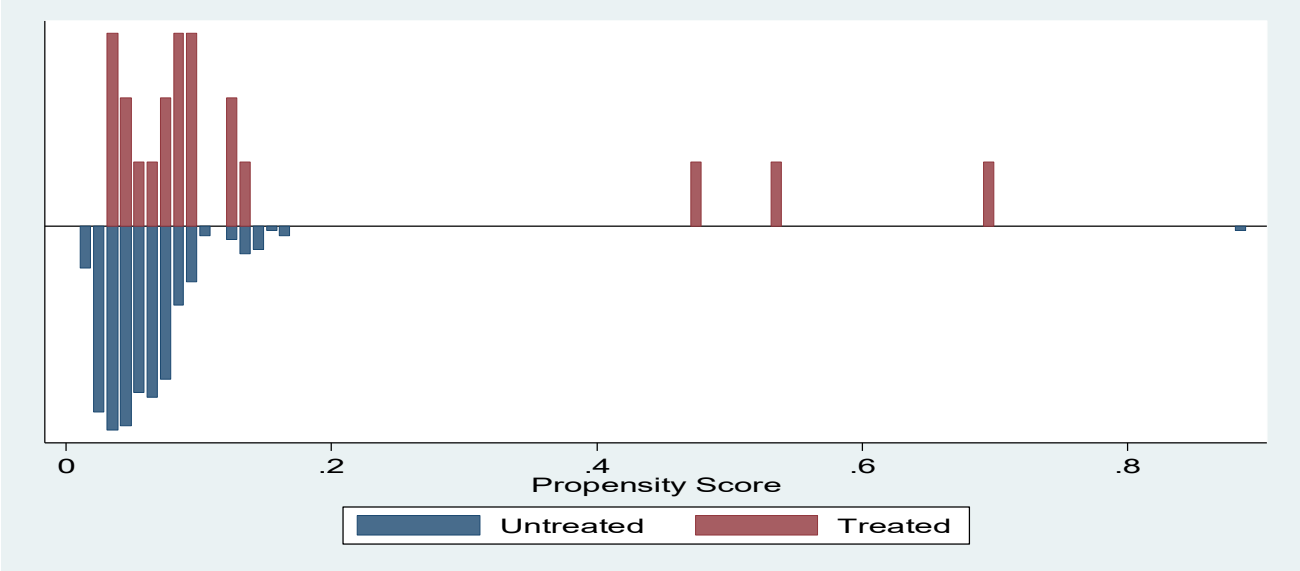
- *Manufacturing sector: balancing property and propensity scores*



propensity score distribution for treated and untreated in manufacturing sector

ICT sector

- *ICT sector: balancing property and propensity scores*



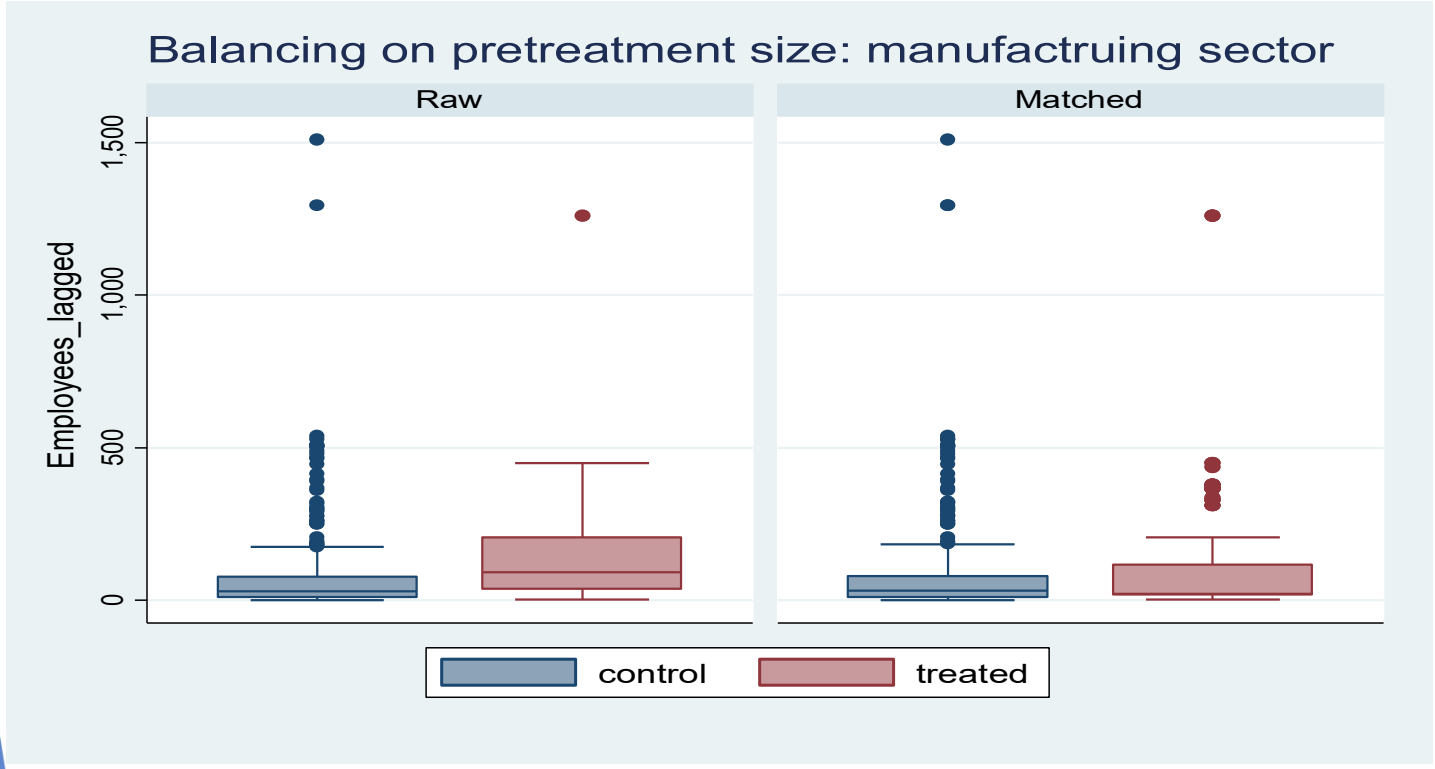
propensity score distribution for treated and untreated in ICT sector

Empirical Analysis and Results

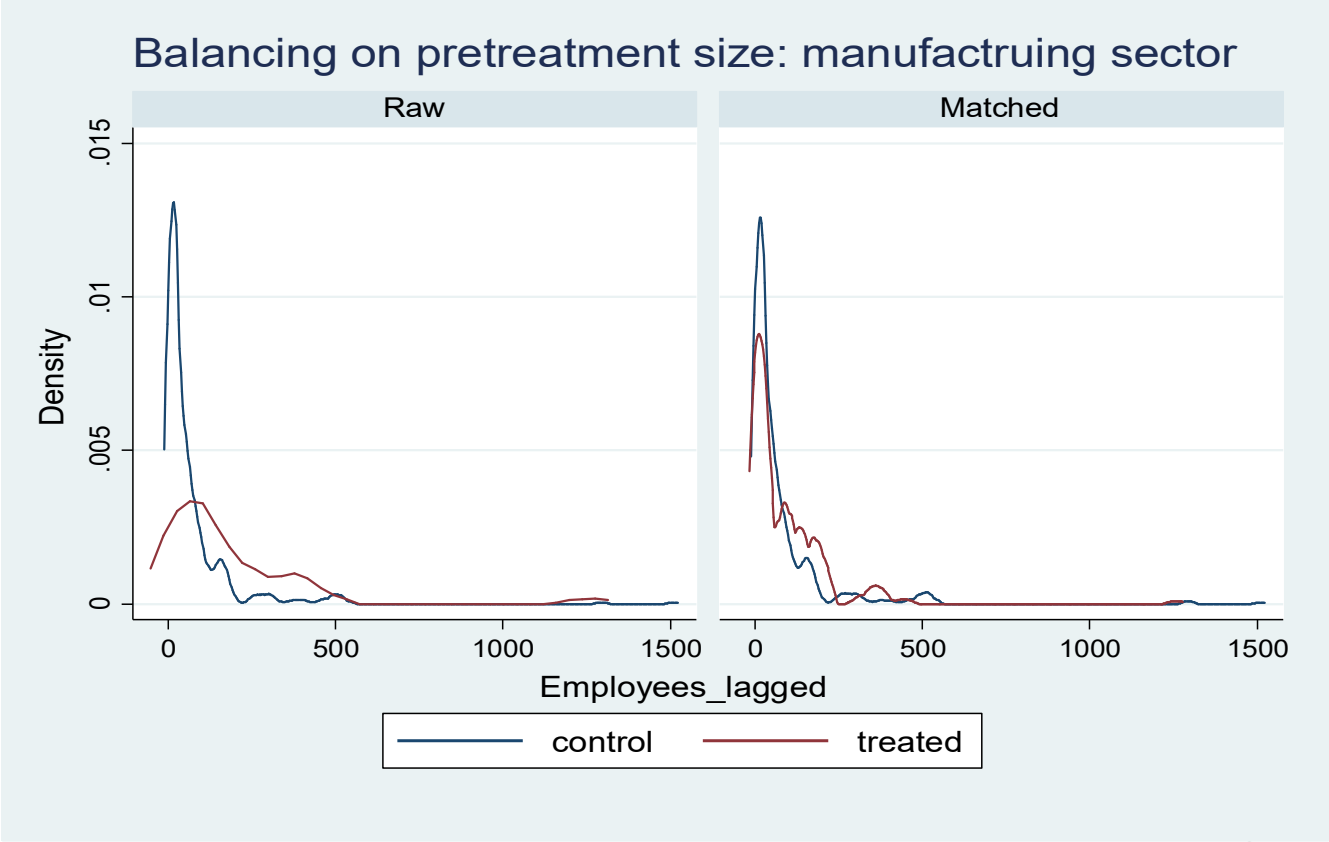
- For ATET: There are 3 outcome measures (TFPCH, TECHCH, EFFCH) being used by 4 different estimators for 5 consecutive years within 2 main industries, hence, 120 effect measures are generated.
- For ATE: There are 3 outcome measures (TFPCH, TECHCH, EFFCH) being used by 2 different estimators for 5 consecutive years within 2 main industries, hence, 60 effect measures are generated.

- As an example:
  - the effect of R&D subsidies on TFP change (tfpch_lagged3) in manufacturing sector and after 3 years (3-year lag): significantly negative (-0.050)
  - The propensity distributions and balancing graphs are as the following:

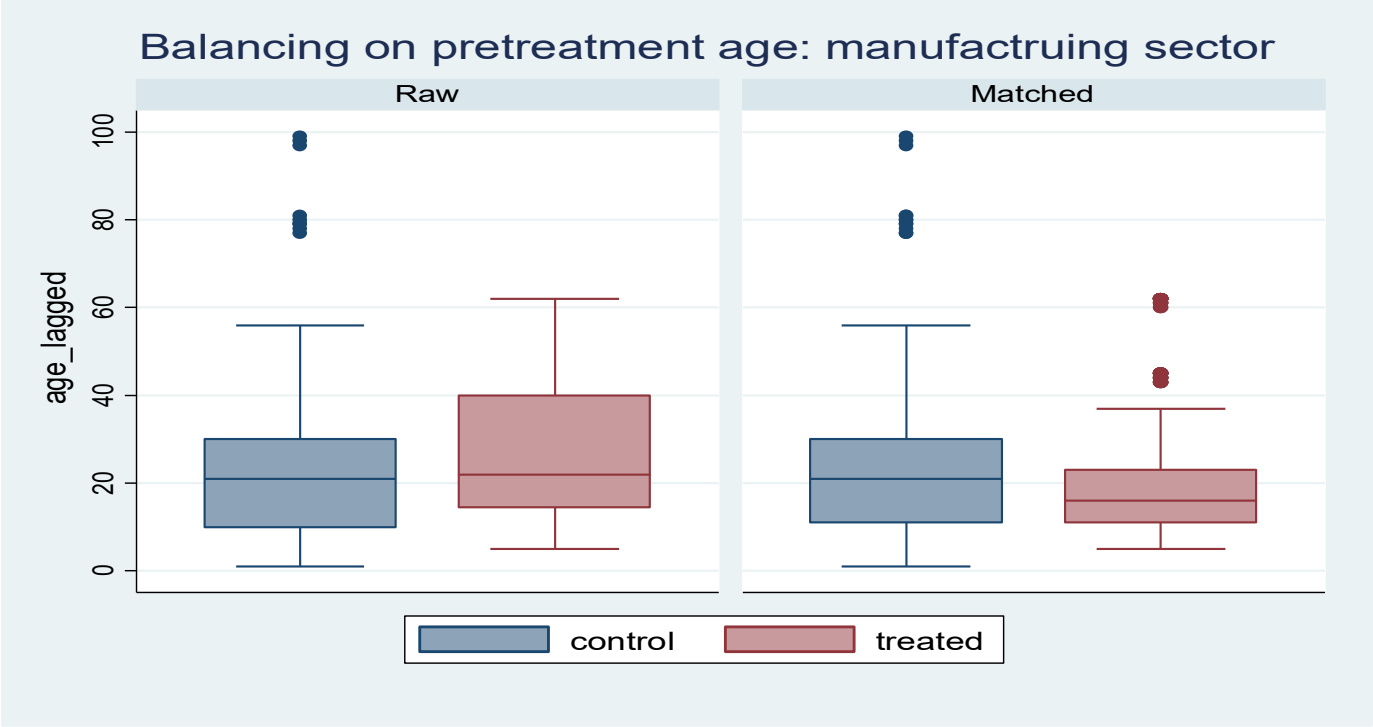
Balancing box-plot graphs for size variable after treatment effect measurement



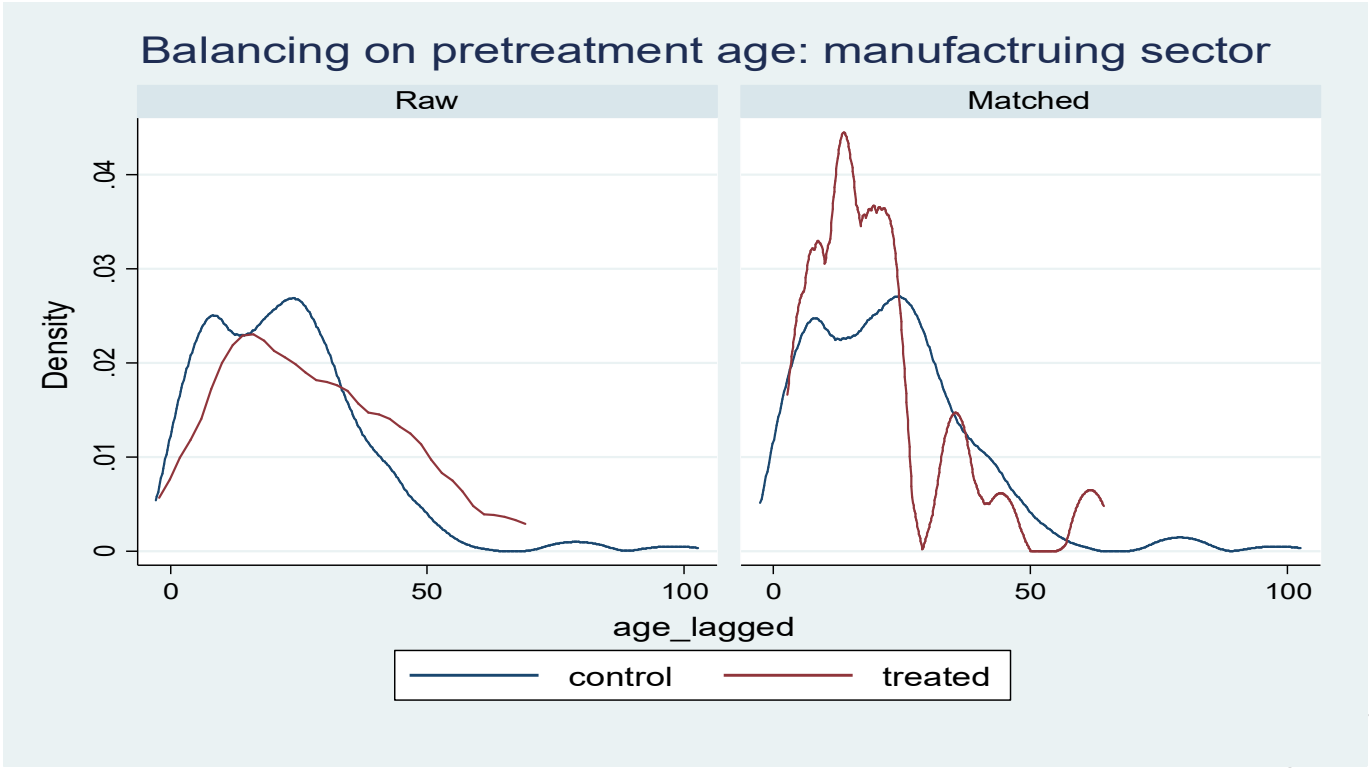
Balancing kernel density graphs for size variable after treatment effect measurement



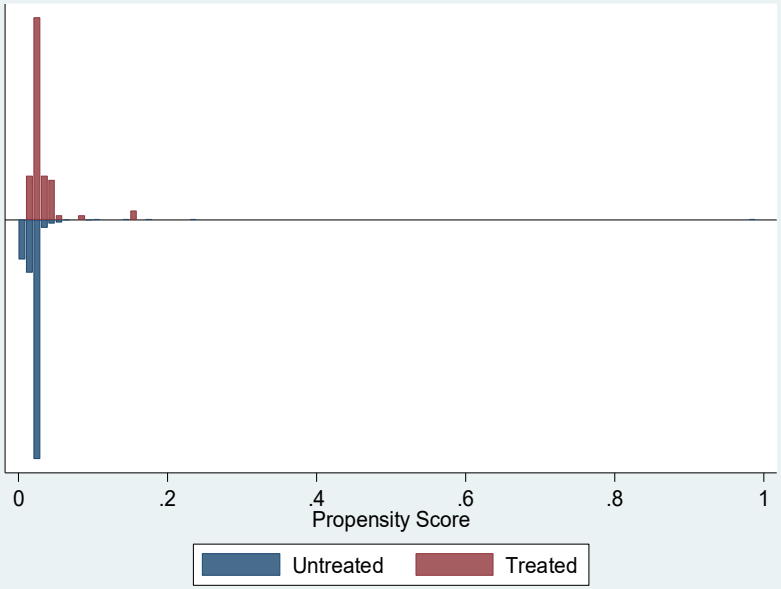
Balancing box-plot graphs for age variable after treatment effect measurement



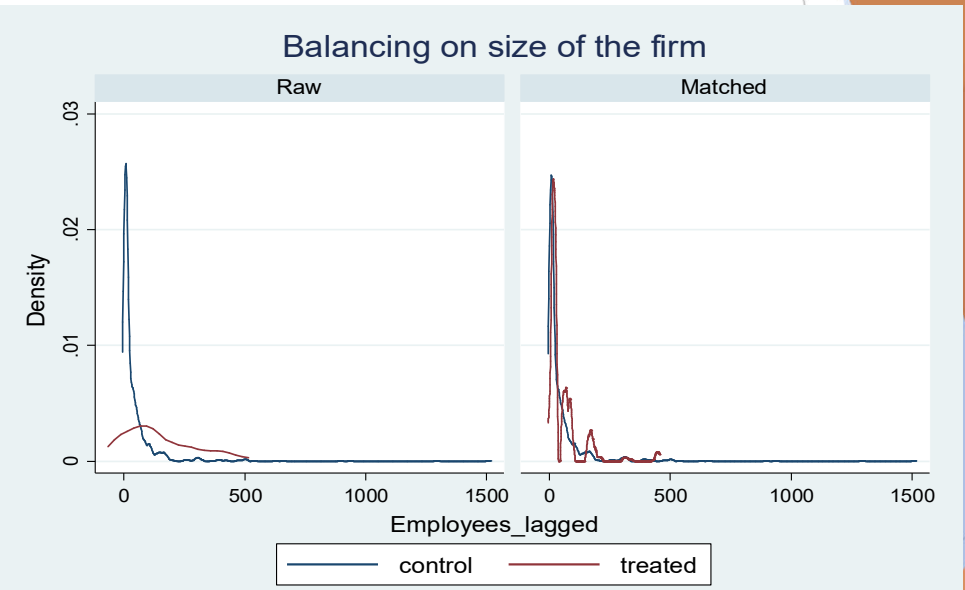
Balancing kernel density graphs for age variable after treatment effect measurement



Low-medium tech industries

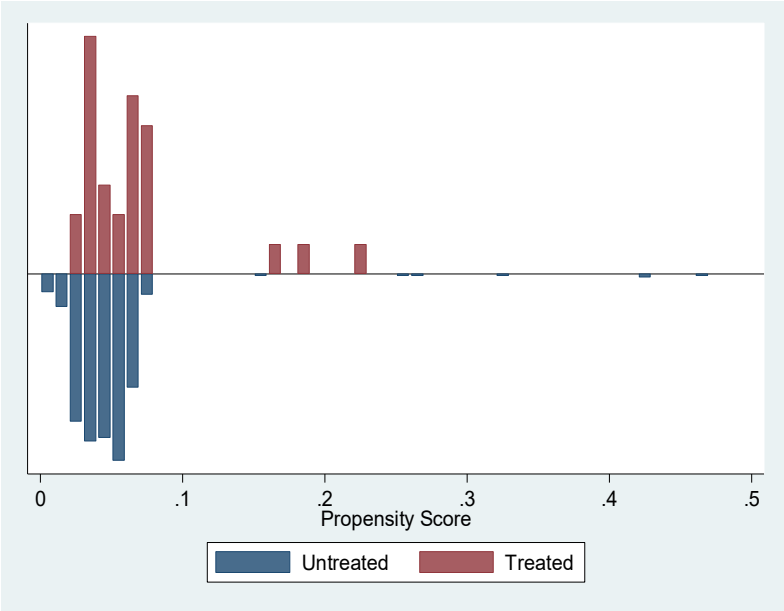


Propensity scores distribution for treated and untreated

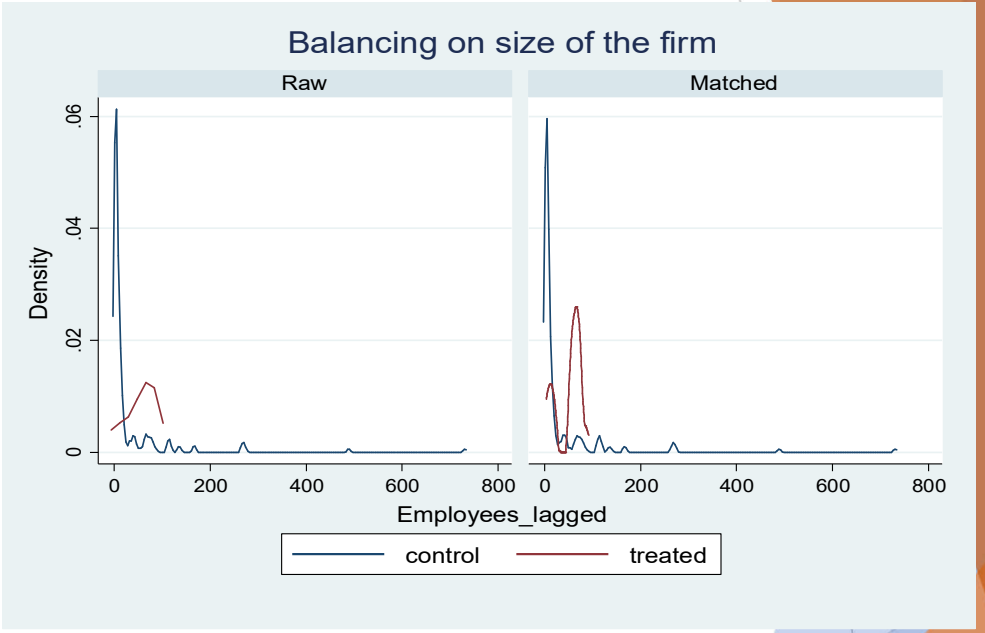


Balancing on size using propensity scores (kernel density)

High-tech industries



Propensity scores distribution for treated and untreated



Balancing on size using propensity scores (kernel density)

Results

	ATE						ATET					
	Short-term†			Long-run††			Short-term			Long-run		
	TFPCH	EFFCH	TECHCH	TFPCH	EFFCH	TECHCH	TFPCH	EFFCH	TECHCH	TFPCH	EFFCH	TECHCH
Manufacturing	#	#	-	-	+	-	+	#	-	#	+	#
ICT	#	#	#	#	#	-	#	#	#	++	+	++
Low-medium Tech	-	-	#	-	--	-	#	#	#	#	#	#
High Tech	#	#	#	#	#	--	+	#	#	#	#	#
Automatic-selection All Obs.	#	#	#	-	#	-	#	#	#	-	#	#
Evaluative selection All Obs.	#	#	#	#	#	#	#	#	#	#	+	-

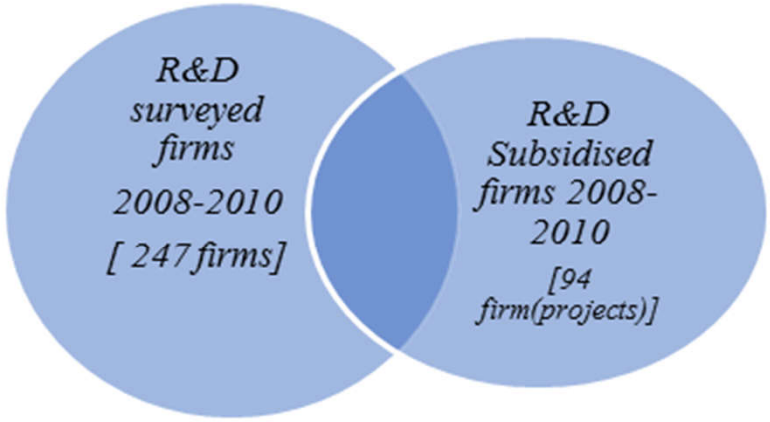
†One/two years †† three to five years

* #: No effect ** In case of being positive/negative for two consecutive years or by two different methods we put more than one +/- sig

Thesis Chapter 4: Estimation of a Public R&D Policy (Program) Structural Model

- Hypotheses 5-8
- The reference 4-staged game model based on Takalo et al. (2013)
  - Objective function of the firm
    - $\Pi(R_i, s_i, X_i, \varepsilon_i) = \exp(X_i\beta + \varepsilon_i)\, lnR_i - (1 - s_i)R_i$
    - $R_i = \frac{exp(X_i\beta+\varepsilon_i)}{1-s_i}$
  - Agency utility function
    - $U(R_i(s_i), s_i, X_i, Z_i, \varepsilon_i, \eta_i) = V(R_i(s_i), Z_i, \eta_i) + \Pi(R_i(s_i), s_i, X_i, \varepsilon_i) - gs_iR_i(s_i) - F_i$
    - $\frac{\partial V}{\partial R} = Z_i\lambda + \eta_i$
    - $s_i^* = 1 - g + Z_i\lambda + \eta_i$
    - $\mathrm{V}(R_i(s_i), Z_i, \eta_i) = (Z_i\lambda + \eta_i)R_i$
  - Application decision equations
    - $d_i = 1\{X_i\beta - Y_i\theta + ln[-E(ln(1 - s_i))] \geq \nu_i - \varepsilon_i\}$
  - Equilibrium
    - A unique Perfect Nash Bayesian Equilibrium

Data and variables



Year	All firms	R&D Subsidized	R&D Survey Respondents	Subsidized and R&D Respondent
2008	92	26	82	16
2009	104	33	84	13
2010	97	35	81	19
Total	**293**	**94**	**247**	**48**

	All potential applicants				Subsidized applicants				Non-Subsidized fi		
	Mean	Std. Dev.	Min.	Max	Mean	Std. Dev.	Min	Max	Mean	Std. Dev	Min.
Size	81.29	172.26	1	1637	57.07	84.90	1	450	92.74	199.91	1
Age	18.34	14.18	0	62	18.40	14.89	0	62	18.32	13.86	1
Sales per employee	310,177.9	808053.3	0	9,042,264	399,056.2	1,227,169	0	9,042,264	268,195.2	500,077.9	0
Board Size	1.23	0.92	1	8	1.12	0.39	1	3	1.28	1.08	1
Exporter (Dummy)	0.52	0.50	0	1	0.53	0.50	0	1	0.51	0.50	0
SME	0.64	0.47	0	1	0.68	0.46	0	1	0.62	0.48	0
R&D Expenditures (year)	593,773.3	820,240.6	4,000	5,521,000	739,562.5	815,468.4	7,000	3,351,000	558,608	819,542.6	4,000
Planned R&D investment					1,298,585	1530747	48,559	8,823,200			
Number of Previous Applications					0.91	1.52	0	6			
Subsidy rate					0.52	0.21	0.05	0.80			
Expected (perceived) subsidy rate					0.54	0.22	0.05	0.80			
Subsidy amount					658,601.2	829126	7,233.9	5,606,350			
Evaluation method					2.06	0.68	1**	3			
Number of observation	293				94				199		

Descriptive statistics of variables applied in estimation of the structural model

Explanatory variable in the econometric estimations	*Application decision equation*	*Subsidy rate equation*	*R&D investment equation*
Age	●	●	●
Log of Employment	●	○	●
Sales/employee	●	○	●
SME	○	●	○
Exporter	●	●	●
Board Size	●	○	●
Industry dummies	●	●	●
Dependent variable	Dummy variable taking value 1 if the firm applies0 for subsidy, and 0 otherwise	Subsidy rate	R&D investment declared in CIS questionnaire
Sample	Potential applicants (Firms which does R&D according to their response to the CIS Survey)	Subsidized Applicants	Subsidized applicants who have responded to CIS survey at the same year of the application acceptance
Number of Observations	293	94	94 for planned investment and 48 for actual investment
Estimation	Probit model	OLS	OLS

variables applied in equation estimations

Econometric equations and estimation of the game model

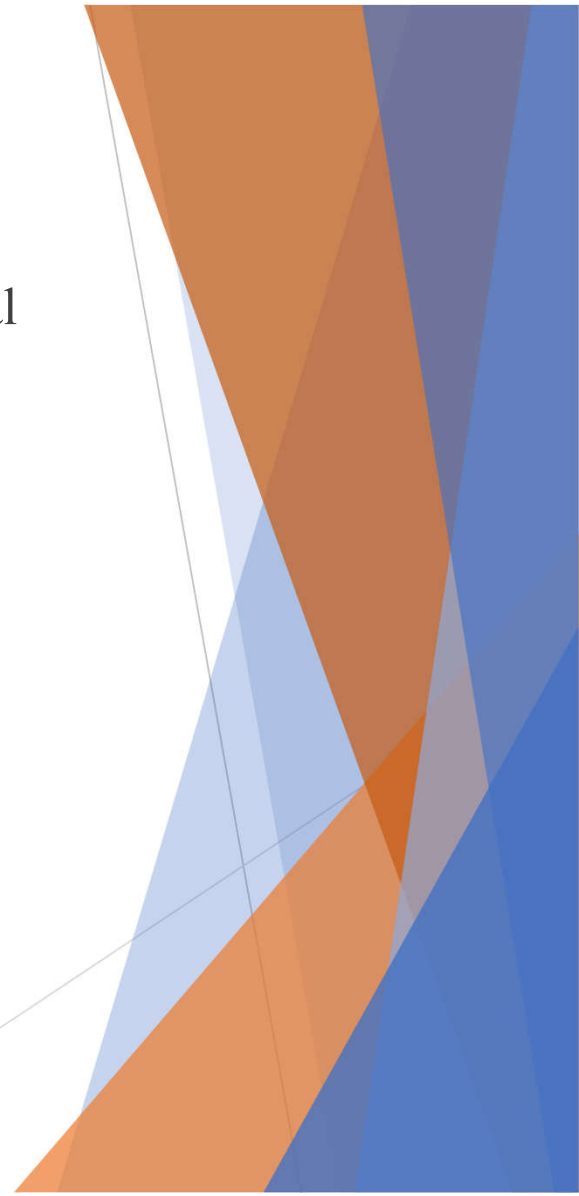
- Investment equation
  - $\ln[(1-\bar{s}_i)R_i^*(\bar{s}_i)] = X_i\beta + \varepsilon_i$
- Subsidy rate equation (Spillover rate equation)
  - $s_i^* = 1 - g + Z_i\lambda + \eta_i$
- Application decision equation
  - $d_i = 1\{X_i\beta - Y_i\theta + ln[-E(ln(1-s_i))] \geq \nu_i - \varepsilon_i\}$
- Statistical assumptions
- Variables with high Variance Inflation Factors (VIFs) and multicollinearity were dropped.

Model Estimation Results

Variables	Subsidy Rate Equation (9)	Application decision Equation (10)	R&D Investment variable: the Planned R&D expenditures Equation (12)	R&D Investment variable: the annual R&D expenditures Equation (12)
Age	**-0.002*** **(0.001)**	0.006 (0.006)	**-0.027***** **(0.008)**	-0.014 (0.013)
Log of Employment	_	**-0.167**** **(0.68)**	**0.622***** **(0.95)**	**0.53***** **(0.14)**
Sales/employee	-0.000 (0.00)	**-0.000*** **(0.00)**	**0.000**** **(0.00)**	0.000 (0.00)
Exporter	-0.087 (0.054)	0.20 (0.20)	0.048 (0.27)	0.56 (0.53)
Board Size	—	**-0.204*** **0.124**	-0.20 (0.24)	0.21 (0.44)
SME	-0.058 (0.055)	_	_	_
Industry sector dummies	**0.185**** Δ **(0.084)**	Significant for 3 out of 4 sectors	**-1.00**** Δ **(0.397)**	Not Sig. for any sector._
Constant	**0.655***** **(0.048)**	0.072 (0.28)	11.38 (0.41)	**3.009***** **(0.076)**
R-Squared	0.26	0.058 (pseudo R2)	0.51	0.44
Number of Observations	94	293	94	48

Investment Equation Estimation

- The effect of explanatory firms' characteristics on the marginal profitability of R&D projects
- Dependent variable: Annual R&D expenditure
  - Larger firms obtain a higher marginal profitability to R&D
- Dependent Variable: Planned R&D investment
  - Larger firms obtain a higher marginal profitability to R&D



Subsidy rate equation (Spillovers rate) estimation

- Coefficients can be interpreted as marginal effects of R&D on spillovers
- The total number of observations: 94
- Age has a slight negative effect on subsidy rate, i.e. younger firms are expected to generate higher spillovers.

Application Decision Estimation

- Larger firms are less probable to apply. One interpretation can be larger firms are less financially restricted.
- The firms with more board members are less eager to apply for R&D subsidies. One interpretation is that the larger board member may lead to higher conflict to make decision on application.

The effect of subsidies on additional R&D

	Mean	Std. dev.	Min	Max	Observations
The additional R&D expenditure (regarding planned R&D investment)	-283626.8	1,339,751	-7,886,245	3,558,113	94
The additional R&D expenditure (regarding actual R&D investment)	-1,331,523	1,413,050	-6,456,908	-95,408.49	48

The difference between the optimal R&D expenditure (predicted by model) and the planned/ realized R&D spending

The effect of subsidies on spillovers effect

	Mean	Std. Dev.	Min	Max	Observations
Spillovers by planned investment	647,364.4	753,545.9	27794.08	4,709,812	94
Spillovers by actual investment	343,899	393,903.4	3.093893	1728.418	48
Spillover rate	0.519	0.11	0.25	0.79	94

The spillovers and spillover rate generated by subsidized firms' R&D investment

Review

- Estimation of equations for a modified reference structural model for public R&D policy using regional data sets related to R&D grants allocation of a regional authority to firms in province of Trento, Italy
- Equations: application decision, subsidy rate and R&D investment equations.
- The theoretical model structure related to agency's profit function allows to measure the firms' characteristics effect on spillover rate.

Thank You