Productivity Effects of CAP Investment Support: Evidence from Sweden using Matched Panel Data

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Good Practice Workshop “Methods for Assessing Impacts of Rural Development Programmes 2007-2013”, 4-5 July Palermo (ITALY)

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- Context of evaluation
- Method
- Data
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- Strengths and weaknesses of method
- Lessons and recommendations

Context of evaluation

- Ex-post evaluation of The Swedish RDP 2007-2013
- Four evaluation teams from Universities in Sweden
- Jönköping university:

Axis 1	111 – Vocational training and information actions
	112 – Setting up young farmers
	121 – Modernization of agricultural holdings
	123 – Adding value to agricultural and forestry products
	124 – Cooperation for development of new products
	125 – Infrastructure
Axis 3	311 – Diversification into non-agricultural activities
	312 – Support for business creation and development
	313 – Encouragement of tourism activities

Context of evaluation

Common Evaluation Question (CEQs) addressed:

Axis 1	**CEQ15: How and to what extent has the measure contributed to improving the competitiveness of the beneficiaries?**

Context of evaluation

Indicators of competitiveness and data:

- Labour productivity (value added per employee)
- Total Factor Productivity (TFP)
- Detailed firm–level data that comprise all active firms in Sweden

Method

Challenges

- Lack of random assignment
- Agricultural firms that received support (measure 121) are more productive and capital intensive
- Simple mean value comparisons between support receiving and non-support receiving firms will result in biased estimates (Rosenbaum and Rubin, 1983)
- Firms can receive different levels of subsidies depending on the nature of the investment project and the characteristics and choice of the firm
- Firms can receive support for different types of investments
- Firms can receive multiple supports
- Results in selection bias, heterogeneous treatment effects and interaction effects

Method

Problem formulation

- Measure of interest is the counterfactual mean difference in the outcome variable, Average Treatment Effect on Treated (ATT):

$$y_{ATT} = \frac{1}{N_i} \Sigma_{i \in T} [y_i(1) - y_i(0)] \quad (1)$$

- The problem using non-randomized data: counterfactual mean is unobserved
- Solution: estimate a control group that has as similar as possible characteristics as the treatment group

Method

Problem formulation

- Literature criticizes the PSM method for being ad-hoc and inefficient (Imbens 2000; Blackwell et al. 2009)
- Requires a process in which the user determines the size of the matching solution ex-ante, checks for balance ex-post and then re-specifies the matching (… until acceptable)
- May counteract goal (reduce bias in the estimation of ATT), as improved balance on some covariates decreases the balance on other covariates (Iacus et al. 2008)

Method

Coarsened Exact Matching (CEM)

- Iacus et al. (2008) propose a matching method for estimating the ATT
- Derived from exact matching theory (Imbens 2000)
- Balance between control and treatment group chosen ex-ante
- Adjusting the imbalance on one covariate does not affect the balance of any other e.g., Monotonic Imbalance Bounding (Blackwell et al. 2009)
- As matching is done before analysis it reduces the degree of model dependence (Ho et al. 2007)
- Temporarily and ex-ante coarsen each pre-treatment covariate, exact match on the coarsened data and then use the un-coarsened values of matched units in subsequent regression analysis

Method

Coarsened Exact Matching (CEM)

Overall balance given by:

$$\mathcal{L}_1(f,g) = \frac{1}{2}\Sigma_{\ell_1,\ldots,\ell_k}|f_{\ell_1,\ldots,\ell_k} - g_{\ell_1,\ldots,\ell_k}| \quad (2)$$

Generates weights (w_i) included for all observations in subsequent regression

$$w_i \begin{cases} 1, if\ T_i = 1, \\ 0, \quad if\ T_i = 0\ and\ i\ \notin\ M_2^A\ for\ all\ A, \\ \frac{m_1^A}{m_2^A}\frac{m_2}{m_1},\ if\ T_i = 0\ and\ i\ \in\ M_2^A\ for\ one\ A. \end{cases} \quad (3)$$

Method

Fixed effects panel with CEM weights (DiD):

$$y_{it} = \beta_0 + \beta_1' I_{it} + \beta_2' E_{it} + \zeta T_i + \tau_t + \nu_i + \varepsilon_{it} \quad (4)$$

$$y_{it} = \beta_0 + \beta_1' I_{it} + \beta_2' E_{it} + \zeta T_i + \rho \Gamma_i + \tau_t + \nu_i + \varepsilon_{it} \quad (5)$$

where

y_{it} = *TFP or value added per employee*

I_{it} = *vector of firm specific characteristics*

E_{it} = *vector of external characteristics*

T_i = *binary treatment effect; 1= treated, 0= untreated*

Γ_i = *continuous treatment effect; support/turnover*

τ_t = *yearly fixed effects*

ν_i = *firm fixed effects*

ε_{it} = *idiosyncratic error term*

Hypotheses

Negative effect on productivity:

- firms adjust investment behavior and realize those that grant subsidies in favor of more productive (Olson 1982)
- lack and slack of effort to seek cost improving methods (Bergstrom 2000)
- lowers the motivation to work efficiently and seek most productive methods as firms increase their dependence on subsidies as a source of income (Zhu et al. 2012)

Positive effect on productivity:

- wealth and insurance effect from improved and stable access to capital (Hennessy 1998)
- investment induced productivity gains as a result of improved access to credit and possibilities to adopt new technology (Blancard et al. 2006; Serra et al. 2008)

Data

- Firm-level data from Statistics Sweden
- Data on support receiving firms (type of support and amount) from The Swedish Board of Agriculture
- 6967 firms where granted support 2007-2012
- 70% can be matched to firm-level data by identity numbers
- Agricultural firms are identified using Standard Industrial Classification (SIC) codes
- Time period of analysis 2007-2012
- Unbalanced panel of 66 753 agricultural, food and forestry firms (210 780 observations in panel)

Dependent variables

- Firm labour productivity and Total Factor Productivity are indicators of competitiveness (Latruffe 2010; Rizov et al. 2013)
- Labour productivity measured as value added per employee
- TFP estimated using the Levinsohn and Petrin (2003) two stage approach:

$$y_{it} = \beta_0 + \beta_l l_{it} + \beta_k K_{it} + \beta_m m_{it} + \zeta_{it} + \eta_{it} \quad (6)$$

$$TFP_{it} = \widehat{\eta_{it} + \varepsilon_{it}} = y_{it} - \hat{\beta}_l l_{it} - \hat{\beta}_k k_{it} - E[\zeta_{it} | \zeta_{it-1}] \quad (7)$$

Independent variables

Variable	Definition
Internal characteristics I_{it}	
Capital	Value of material assets
Labour	Number of full-time equivalent employees
Age	Average age of employees
Education	Share of employees with three or more years of university education
Female	Percentage of female employees
Exports	Dummy=1 if the firms is exporting
Multi-firm	Dummy=1 if the firm has more than one establishment
Investment support T_i	Dummy=1 if firms has received investment support
Investment support Γ_i	Amount of support divided by firm turnover
External characteristics E_{it}	
Population density	Population per square kilometer in municipality
Industry diversity	Distribution of employees across industries in municipality
Specialization	Locational quotient measuring the municipal share of employees within agriculture relative to the national share
Land	Share of agricultural land in municipality

Main findings

Effect of investment support on TFP (all firms)

Variable	FE	FE–CEM	FE–CEM
Investment support T_i	0.136*** (0.012)	0.108*** (0.016)	0.121*** (0.016)
Investment support Γ_i	-	-	-0.349*** (0.054)
Industry	YES	YES	YES
Year	YES	YES	YES
Firms	67749	66753	66753

****, ** denote significance at the 1 and 5 percent respectively. Internal and external characteristics are included in all estimations.*

Main findings

Results FE–CEM; effect of investment support on TFP

Variable	1 empl.	> 1 empl.	Diary	Crop
Investment support T_i	0.136*** (0.026)	0.017 (0.016)	0.157** (0.025)	0.106** (0.040)
Investment support Γ_i	-0.354*** (0.069)	-0.347*** (0.082)	-0.273*** (0.204)	-0.430** (0.200)
Industry	YES	YES	YES	YES
Year	YES	YES	YES	YES
Firms	58974	13658	6993	25595

****, ** denote significance at the 1 and 5 percent respectively. Internal and external characteristics are included in all estimations.*

Main findings

Results FE–CEM; effect of investment support on labour productivity

Variable	1 empl.	> 1 empl.	Diary	Crop
Investment support T_i	0.135*** (0.027)	0.034** (0.014)	0.123*** (0.025)	0.116** (0.040)
Investment support Γ_i	-0.356*** (0.026)	-0.367*** (0.082)	-0.309*** (0.059)	-0.479** (0.199)
Industry	YES	YES	YES	YES
Year	YES	YES	YES	YES
Firms	58974	13658	6993	25595

****, ** denote significance at the 1 and 5 percent respectively. Internal and external characteristics are included in all estimations.*

Main findings

Results FE–CEM; effect of investment support to renewable energy

Variable	TFP	TFP	Labour prod.
Investment support T_i Renewable energy	0.115*** (0.031)	0.133*** (0.032)	0.151*** (0.032)
Investment support Γ_i Renewable energy	-	-0.326 (0.173)	-0.345 (0.172)
Industry	YES	YES	YES
Year	YES	YES	YES
Firms	66753	66720	66720

****, ** denote significance at the 1 and 5 percent respectively. Internal and external characteristics are included in all estimations.*

Another question that arises with regard to policy instruments that aim at long-term changes e.g., modernization and increasing the competitiveness of agricultural holdings is if the impacts are temporarily or permanent?

	Labour Productivity		TFP	
	Coef. (Std. Err.)	Marginal effect	Coef. (Std. Err.)	Marginal effect
Measure (121) t+1	0.087 (0.092)	-	0.080 (0.090)	-
Measure (121) t+2	-0.016 (0.084)	-	-0.026 (0.073)	-
Measure (121) t+3	-0.018 (0.081)	-	-0.015 (0.049)	-
Measure (121) t+4	**0.218**** (0.079)	0.010	**0.165**** (0.079)	0.010
Measure (121) t+5	**0.319***** (0.074)	0.017	**0.179***** (0.074)	0.017

Addressed in the panel data model by including lags and testing their significance empirically (as in Petrick and Zier, 2011).

Strengths and weaknesses of method

Strengths

- Improved balance between control and treatment group
- Detailed firm-level data across Sweden
- Comparisons between agricultural sub-sectors and investment types
- Continuous treatment effect

Weaknesses

- Difficult to disentangle the effects on one specific support as firms can receive many
- Firms can be treated several times during the program period
- Unable to include firms that where granted support after 2012 in the analysis

Lessons and recommendations

Methodological

- Assuming random assignment result in biased estimates
- Assuming a binary treatment effect only tells part of the story
- Exist strong heterogeneity in the treatment outcome with respect to different levels of capital subsidies
- Findings lend support to the theoretical hypotheses on non-linear treatment effects (e.g., Zhu et al. 2012)

Policy

- Firms granted support have a higher *level* of productivity compared to the control group (ATT 10 percent)
- Significant negative productivity effect attached to a higher degree of subsidies as a source of income
- Ratinger et al. (2015) show that measure 121 can improve its efficiency if targeted to small and medium sized firms

Lessons and recommendations

- The negative (continuous) productivity effect indicates inefficiencies (or rent seeking) attached to higher level of supports
- Lack or slack of effort to seek cost improving methods – misallocation of productive resources
- May indicate deadweight attached to high and persistent level of support

End

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Appendix

Summary statistics; number of granted supports 2007-2015

Type of investment	Number
Investment support to diary firms of which 766 to milk robot	**1977**
Renewable energy	**1193**
Miscellaneous	**3797**
Total	**6967**

Summary statistics; number of granted supports 2007-2012

Type of firm (SIC)	Number of granted firms
Agriculture	**4377**
Forestry	196
Food	28
Miscellaneous	260
Total	4861

Firms that we where able to match to firm data

Type of agricultural firm (SIC)	Number of granted firms
Crop	632
Diary	1635
Miscellaneous	2110
Total	**4377**

Summary statistics (simple mean value comparison)

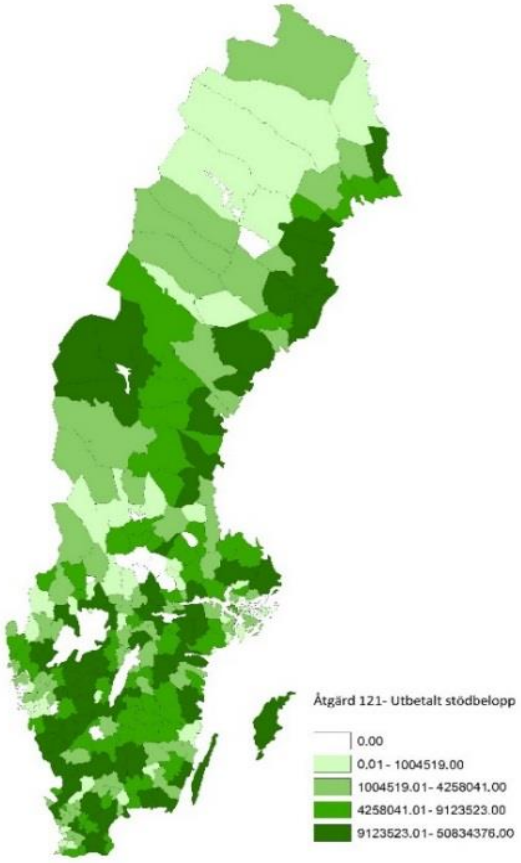
Variable	$T_i = 1$	$T_i = 0$	Total sample
TFP	**178.70**	**119.71**	122.85
Value added	**794.25**	**331.46**	351.28
Capital	**8639.16**	**3897.04**	4086.33
Labour	**2.82**	**2.32**	2.32
Age	**42.56**	**52.93**	52.78
Education	0.11	0.12	0.12
Exports	0.02	0.01	0.01
Population density	**53.35**	**119.18**	116.56
Land	0.25	0.21	0.21

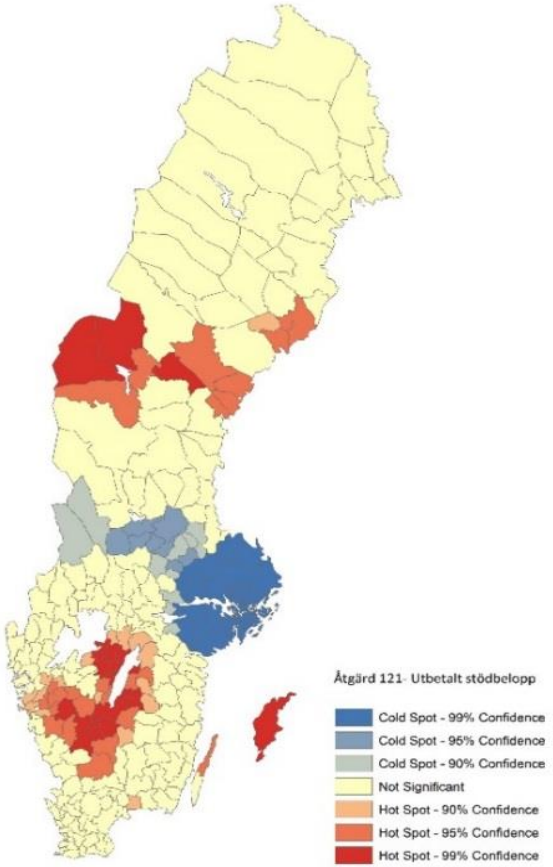
Major findings (all variables)

Results; effect of investment support on TFP

Variable	1 empl.	> 1 empl.	Diary	Crop
Age	-0.129** (0.058)	-0.014 (0.037)	0.086** (0.040)	0.013 (0.102)
Education	0.049 (0.053)	0.156*** (0.031)	0.044 (0.068)	0.074 (0.050)
Female	-0.007 (0.048)	-0.251*** (0.023)	-0.174*** (0.042)	-0.092 (0.046)
Exports	0.072** (0.031)	0.013 (0.021)	0.016 (0.067)	0.062 (0.041)
Multi-firm	-	-	-0.591*** (0.017)	-0.585*** (0.018
Investment support T_i	**0.136*** **(0.026)**	**0.017** **(0.016)**	**0.157**** **(0.025)**	**0.106**** **(0.040)**
Investment support Γ_i	**-0.354*** **(0.069)**	**-0.347*** **(0.082)**	**-0.273*** **(0.204)**	**-0.430**** **(0.200)**
Population density	-0.010 (0.018)	-0.033 (0.024)	0.065 (0.049)	-0.053 (0.040)
Specialization	-0.013 (0.033)	0.034** (0.019)	0.054 (0.077)	-0.047 (0.056)
Industry diversity	0.283*** (0.083)	0.139 (0.093)	-0.032 (0.225)	0.220 (0.133)
Land	0.097 (0.127)	0.081 (0.159)	-0.776** (0.369)	0.380 (0.215)
Industry	YES	YES	YES	YES
Year	YES	YES	YES	YES
Firms	58974	13658	6993	25595

****, ** denote significance at the 1 and 5 percent respectively.*


Åtgärd 121- Utbetalt stödbelopp
0.00
0.01 - 1004519.00
1004519.01 - 4258041.00
4258041.01 - 9123523.00
9123523.01 - 50834376.00


Åtgärd 121- Utbetalt stödbelopp
Cold Spot - 99% Confidence
Cold Spot - 95% Confidence
Cold Spot - 90% Confidence
Not Significant
Hot Spot - 90% Confidence
Hot Spot - 95% Confidence
Hot Spot - 99% Confidence

Results of CEM match

Matchningsalgoritm 1	L1	Medelv.	25%	50%	75%
Antal anställda	0.238	0.487	0	0	2
Företagets tillgång till Kapital	0.385	3299	1696	3086	5366
Andel högutbildade	0.008	0	0	0	0
Densitet i kommunen	0.035	-2.99	-0.72	-1.90	-1.65
Tillgång till jordbruksmark i kommunen	0.103	0	0	0	0
SNI	0.221	-0.221	1	0	-1
Multivariate $\mathcal{L}_1$ distance: 0.815, antal strata: 1466, antal matchade strata:241					
Matchningsalgoritm 2					
Kapital	0.384	3 236	1 696	3 085	5 364
Andel högutbildade	0.01	0.00	0	0	0
Densitet	0.035	-2.99	-0.722	-1.90	-1.65
Mark	0.103	0.005	0.002	0.002	0.001
SNI	0.221	-0.221	0	0	-1
Multivariate L_1 distance: 0.765, antal strata: 1389, antal matchade strata: 241					
Matchningsalgoritm 3					
Kapital	0.415	3 873	1 740	3 243	5 994
Mark	0.095	0	0.002	0.002	0.001
SNI	0.237	-0.236	0	0	-1
Multivariate $\mathcal{L}_1$ distance: 0.590, antal strata: 97, antal matchade strata: 47					