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Circular Economy Innovations, Growth and Employment at the Firm Level: Empirical Evidence from Germany

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1. Introduction

- The circular economy (CE) principally focuses on savings on the shares of material, energy, and capital embedded in the product.

- The circular economy is a key element in greening an economy and is in the focus of the political debate. Therefore, the performance and employment effects of CE innovations are crucial

- Use of the Community Innovation Survey (CIS) 2014 containing detailed information on the CE

Structure

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2. Definition and scope of the Circular Economy (CE)

Definition of the Circular Economy (Korhonen et al. 2018:39):

"Circular economy is an economy constructed from societal production-consumption systems that maximizes the service produced from the linear nature-society-nature material and energy throughput flow. (…). Successful circular economy contributes to all the three dimensions of sustainable development."

CE innovations at the firm-level

- Innovation activities of firms to adapt firm processes and products leading to a reduction of material and energy consumption or increasing the recyclability or lifetime of products

- CE innovations are a subset of the broader concept of eco-innovations also including the reduction of air pollution or noise emissions

3. Impacts of the CE on performance and employment: Transmission channels and literature overview

Why do CE measures might lead to a better performance and more employment:

1) Energy and material savings of processes and products lead to improvements in competitiveness and thus to a higher product demand (in line with the Porter hypothesis)

2) Consumers are willing to pay more for the added ecological value caused by CE measures

3) Positive reputation effects for firms realizing CE improvements

4) CE innovations might have negative employment effects if they are accompanied by a higher labor productivity or if more labor-intensive products are substituted

5) Positive employment effects because of an increased product demand and/or additional investments for the realization of CE innovations

Hypotheses

H1: Lower production costs induced by CE innovations are positively linked to the competitiveness of firms and firms' sales growth without hurting the firms' financial standing.

H2: CE innovations and employment are positively linked because higher competitiveness dominates over an increase in labor productivity and the substitution of more labor-intensive products within firms.

Literature overview

- Extensive literature on the performance effects of eco-innovations in general (for an overview see Ghisetti 2018)

- Relative rare literature on the employment effects (see e. g. Horbach, Janser 2016 for an overview)

1) Performance effects

- Ghisetti (2018:59): "As a matter of fact, the meta-analysis of the literature by Horváthová (2010) summarizes that 15% of the studies found a negative return of going green, 55% a positive return, and 30% found no significant effect.“

- Ghisetti, Rennings (2014): Based on the German CIS (2008 and 2010) the authors find that innovations leading to a reduction in the use of energy or materials improve the competitiveness of firms whereas other, more end-of-pipe oriented eco-innovations might even hamper firms' competitiveness.

- Antonietti, Marzucchi (2014): Based on a firm-level dataset of Italian manufacturing the authors show a positive productivity effect for medium-high performing firms of investments that help reducing raw materials.

- Horbach (2018): An increased use of renewables leads to a higher performance whereas measures to reduce water consumption are negatively correlated to turnover development, database: Eurobarometer 2013.

- Flachenecker, Kornejew (2019): Evidence for positive effects of material productivity improvements on microeconomic competitiveness in the EU.

- Soltmann et al. (2015): U-shaped performance effect of eco-innovations from 1983 to 2009 (patent data for 12 OECD countries). The marginal costs of green inventions should have decreased over time.

- Lotti, Marin (2017): Lower returns of eco-innovations compared with other innovations in the short run based on a patent analysis of Italian firms.

2) Employment effects

- Pfeiffer, Rennings (2001): Cleaner production is more likely to increase employment compared to end-of-pipe technologies.

- Horbach (2010): Positive and significant influence of eco-product innovations on employment based on the establishment panel of the IAB.

- Horbach, Rennings (2013): Eco-innovative firms are in general characterized by a significantly more dynamic employment development (especially cleaner technologies), data: German CIS 2008.

- Licht, Peters (2014): Both environmental and non-environmental product innovations trigger employment growth, but non-environmental product innovations are more likely to increase employment, German CIS 2008 data.

- Gagliardi et al. (2016): Link between eco-innovation and job creation at the firm level for 4,507 Italian firm matched with patent records for the period 2001 to 2008. Strong positive impact of eco-innovation on the creation of long-run jobs.

- Kunapatarawong, Martínez-Ros (2016): Positive relationship between eco-innovation and employment. The employment effects are stronger for firms in the so-called ‘dirty’ industries, data: Spanish Technological Innovation Panel (PITEC) for 2007 to 2011.

- Horbach, Janser (2016): Innovation and industry agglomeration foster employment growth in establishments in the environmental sector, data: IAB establishment panel 2012

4. Data basis and descriptive results

Combination of three data bases:

- Community Innovation Survey (CIS) of the reference year 2014 containing a separate module on eco-innovations, 7,940 firms
- Use of the CIS 2016 for the turnover and employment variables
- Regional patent data at the NUTS 3 level
- Data on the financial standing of the firms from the “Verband der Vereine Creditreform (VVC)

Share of firms by different CE innovation fields

CE innovations	Share of firms with significant CE innovations, weighted results (%)
Process innovations	
Reduced energy use per unit of output	10.6
Reduced material use / use of water per unit of output	4.8
Replaced fossil energy sources by renewable energy sources	4.0
Replaced materials by less hazardous substitutes	2.9
Recycled waste, water, or materials for own use or sale	6.4
Product innovations	
Reduced energy use	7.3
Improved recycling of product after use	3.2
Extended product life through longer-lasting, more durable products	3.7
All CE innovations	27.0

Estimation strategy

Use of Quantile regressions

The quantile regression is semiparametric so that there are no assumptions about the parametric distribution of the error term

The qth (0 < q < 1) quantile regression estimator minimizes the objective function over β_q (Koenker 2005, Cameron, Trivedi 2005, 2009):

$$Q(\beta_q) = \sum_{i:y_i \geq x_i'\beta}^{N} q|y_i - x_i'\beta_q| + \sum_{i:y_i < x_i'\beta}^{N} (1-q)|y_i - x_i'\beta_q|$$

β_q instead of β is used showing that different choices of q lead to different values of β. As the objective function is not differentiable, the simplex method is used for a solution.

Different quantiles *q* of the functions for

- Turnover development: T*urnover1416* = f(CE innovation$_{2012\text{-}2014}$, control variables)
- Labor demand: *Emp1416* = f(CE innovation$_{2012\text{-}2014}$, control variables)
- Financial standing in 2016: *Finstanding* = f(CE innovation$_{2012\text{-}2014}$, control variables)
- Labor productivity growth: *Labprod1416* = f(CE innovation$_{2012\text{-}2014}$, control variables)

Circular economy innovations and turnover growth in German firms

Regressors	Dependent variable: *Turnover1416*		
	25% quantile	Median	75% quantile
CE innovation (2012-14)	2.30 (2.10)*	1.42 (1.95)*	-0.41 (-0.37)
Processinno (2012-14)	1.17 (1.05)	2.43 (3.06)**	3.67 (2.84)**
Productinno (2012-14)	1.47 (1.22)	-0.14 (-0.17)	0.43 (0.32)
Export (2014)	-0.27 (-0.23)	-0.37 (-0.43)	-0.01 (-0.01)
Highqual (2013)	-6.37 (-2.32)*	1.66 (0.78)	14.0 (4.25)**
Family (2014)	-3.11 (-2.82)**	-2.71 (-3.79)**	-2.44 (-2.00)*
Compabroad (2014)	-3.01 (-2.57)**	-1.38 (-1.83)+	-3.16 (-2.48)**
Size (2012)	0.08 (0.06)	-0.10 (-2.10)*	-0.14 (-1.47)
West (2014)	1.85 (1.52)	-0.46 (-0.51)	-0.71 (-0.61)
Event1 (M&A, 2012-14)	-1.19 (-0.35)	0.79 (0.46)	-0.27 (-0.09)
Event2 (sale or closure, 2012-14)	-11.6 (-2.78)**	-6.15 (-3.55)**	-7.38 (-3.87)**
Event3 (outsourcing, 2012-14)	1.37 (0.70)	1.30 (0.55)	4.38 (2.14)*
Event4 (new subsidiaries, 2012-14)	3.55 (1.49)	3.05 (1.96)*	1.93 (0.70)

t-statistics shown in parentheses. +,*, ** denote significance at the 10%, 5% and 1% level, respectively. Sector dummies are included but not reported. Robust standard errors. Quantile regressions.

Circular economy innovations and financial standing in German firms

Regressors	Dependent variable: *Finstanding*			
	OLS	25% quantile	Median	75% quantile
CE innovation (2012-14)	6.00 (3.51)**	4.63 (1.69)+	5.13 (3.00)**	6.79 (4.74)**
Processinno (2012-14)	6.68 (3.09)**	6.25 (2.01)*	5.13 (3.02)**	3.50 (1.85)+
Productinno (2012-14)	-0.83 (-0.47)	-0.82 (-0.32)	-1.08 (-0.77)	-0.19 (-0.11)
Patreg0812	0.04 (1.86)+	0.07 (2.00)*	0.03 (1.39)	0.03 (1.17)
Turnov14-16d	6.18 (4.06)**	3.95 (1.63)+	0.05 (0.03)	2.13 (1.50)
Export (2014)	5.13 (2.68)**	7.14 (2.61)**	7.52 (4.38)**	4.84 (2.47)**
Highqual (2013)	-15.3 (-3.50)**	-16.3 (-2.93)**	-15.5 (-5.93)**	-14.5 (-4.59)**
Family (2014)	-7.53 (-3.97)**	-9.30 (-3.33)**	-5.39 (-3.92)**	-6.30 (-3.78)**
Compabroad (2014)	-0.50 (-0.28)	-4.20 (-1.65)+	0.43 (0.28)	1.03 (0.60)
Competitors (2014)	-5.57 (-2.93)**	-6.57 (-2.58)**	-4.04 (-2.70)**	-3.40 (-2.08)*
Size (2012)	1.01 (3.79)**	0.56 (4.22)**	0.55 (5.18)**	4.24 (3.54)**
West (2014)	-0.36 (-0.10)	-4.71 (-0.95)	-3.97 (-1.15)	-3.86 (-1.20)
Type of regression	OLS	Quantile	Quantile	Quantile

t-statistics shown in parentheses. +,*, ** denote significance at the 10%, 5% and 1% level, respectively. Sector dummies and the event variables are included but not reported. Robust and clustered standard errors.

Results for the performance effects

- Firms having introduced CE innovations from 2012 to 2014 are characterized by a significantly higher turnover growth from 2014 to 2016 compared to other firms.

- Furthermore, the CE firms show a significantly better financial standing in 2016.

- In terms of financial standing and turnover development process innovators perform better.

- The regional innovative capacity (NUTS 3 level) where the firm is located measured by the patent dynamics from 2008 to 2012 is positively correlated to the financial standing of a firm.

Circular economy innovations and employment growth in German firms

Regressors	Dependent variable: *Emp1416*			
	OLS	25% quantile	Median	75% quantile
CE innovation (2012-14)	2.43 (2.75)**	2.78 (3.51)**	1.06 (2.34)*	1.00 (1.51)
Turnov12-14d	4.66 (5.13)**	3.86 (5.10)**	3.48 (5.81)**	6.40 (6.89)**
Wage1314	0.10 (2.28)*	0.08 (2.90)**	0.08 (4.82)**	0.20 (6.59)**
Export (2014)	1.08 (1.02)	2.13 (2.25)*	0.06 (0.11)	-0.54 (-0.70)
Highqual (2014)	1.57 (0.69)	-0.78 (-0.49)	0.27 (0.24)	6.73 (3.37)**
Family (2014)	0.66 (0.69)	-2.39 (-2.96)**	-0.14 (-0.31)	3.00 (4.05)**
Pricecomp (2014)	-2.51 (-2.76)**	-2.76 (-3.62)**	-1.48 (-3.24)**	-2.32 (-3.21)**
Size (2012)	-0.28 (-1.20)	-0.68 (-7.28)**	-0.01 (-0.01)	-0.09 (-0.20)
West (2014)	-0.15 (-0.16)	0.85 (1.08)	0.26 (0.58)	-0.09 (-0.10)
Event1 (M&A, 12-14)	0.15 (0.07)	0.12 (0.09)	0.27 (0.42)	-2.95 (-1.08)
Event2 (sale/clos., 12-14)	-7.16 (-3.22)**	-5.32 (-2.57)**	-3.48 (-3.44)**	-2.33 (-1.98)*
Event3 (outsourcing, 12-14)	-4.53 (-2.23)*	-3.27 (-2.16)*	-1.28 (-1.32)	-0.46 (-0.29)
Event4 (new subs., 12-14)	3.02 (1.37)	2.05 (0.98)	2.23 (1.68)+	3.89 (1.54)
Type of regression	OLS	Quantile	Quantile	Quantile

t-statistics shown in parentheses. +,*, ** denote significance at the 10%, 5% and 1% level, respectively. Sector dummies are included but not reported. Robust standard errors.

Results for the employment effects

- CE innovative firms show a positive employment development from 2014 to 2016.
- Not surprisingly, the employment development is also triggered by a growing product demand in the past (turnover dev 2012-2014)
- A high price competition leads to a lower employment.
- Most significant results for the 25% quantile capturing moderate employment changes
- Results for the 75% quantile are insignificant. This quantile already includes jumps of employment (e.g. because of the integration of a new firm or a new product line)

Summary and policy conclusion

- Firms realizing CE innovations show positive effects on their financial standing and a positive turnover development

- The employment development of CE innovative firms is also positive

- All in all, it seems to pay to be circular. Policy measures should promote CE activities especially by reducing information deficits and initial cost barriers

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Thank you for your attention!