The Impact of Environmental Innovation on Employment Growth in Europe

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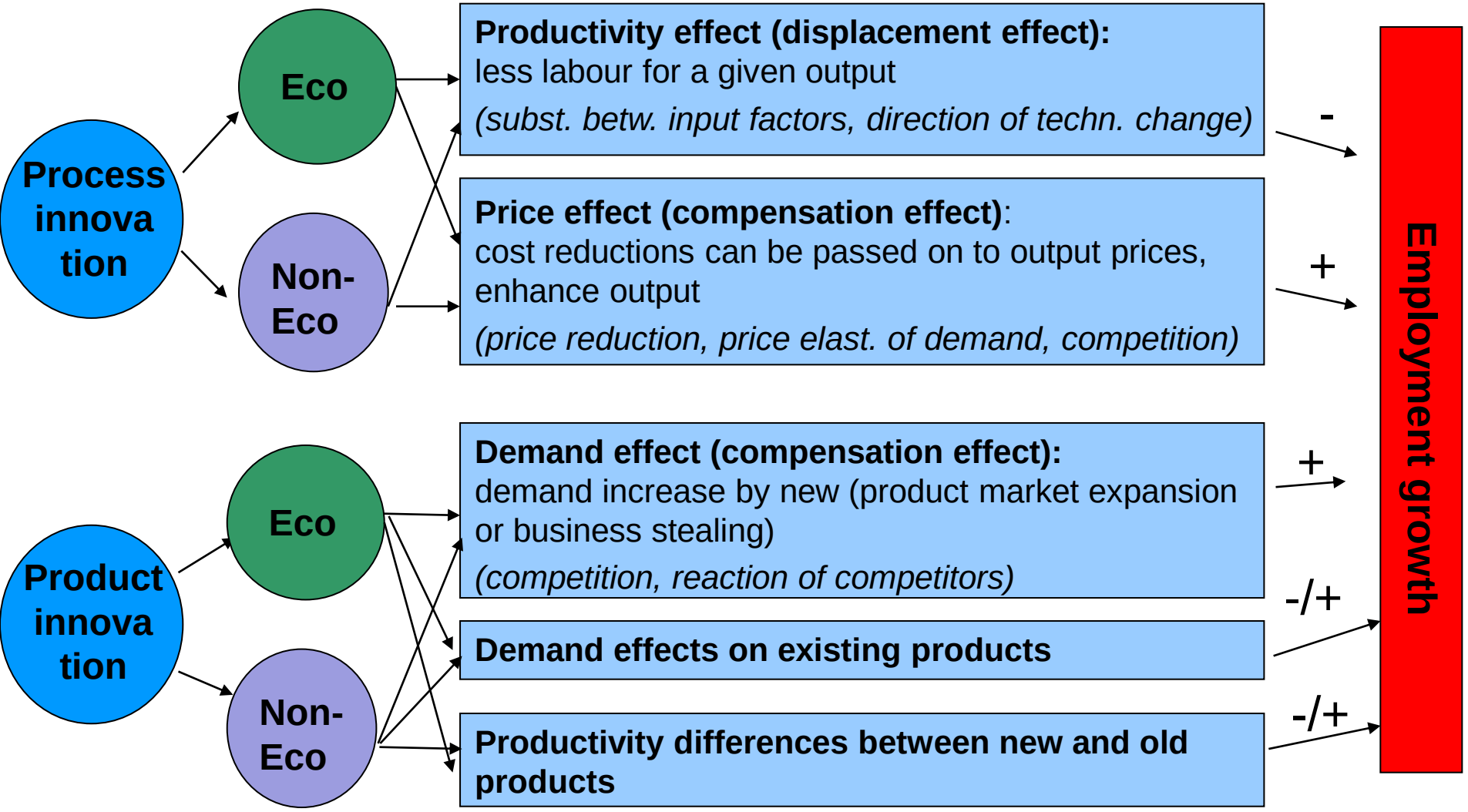
Motivation

- Environmental innovations have been placed at the heart of the Europe 2020 strategy for smart, sustainable and inclusive growth and job creation.
- Eco-innovation Action Plan started in 2011 as part of EU2020
  - complements ambitions of the EU2020 Innovation Union and Resource Efficiency Flagship initiatives.
  - aims at boosting eco innovation by different instruments such as implementing new environmental policy legislations, developing new standards, subsidies for research in eco innovation, mobilizing financial instruments for eco innovation, fostering international cooperation or promoting European innovation partnerships.
  - environmental innovation not just as being crucial for a special industry but that all firms can and should become environmental innovators (“greening of all of the sectors”)
- Environmental innovations are seen as key for Europe’s economy to adjust to environmental and resource constraints.
- In addition to its environmental benefits, policy hopes that green innovations could provide an important contribution to strengthen the competitiveness of firms and, consequently, to the preservation or creation of *new* jobs.

Different channels through which environmental innovation affects employment growth



Key Questions

- What would be the likely employment consequences of a shift towards green innovation in Europe?
  - Are environmental process innovation conducive to employment?
  - Do environmental product innovation stimulate employment?
  - Do environmental product or process innovation create larger or smaller employment changes compared to non-environmental innovations?
  - Are there any differences between countries or sectors in Europe?

Empirical Evidence: Innovation-Employment Link

- Majority: Product innovations stimulated labour demand

  e.g. König et al. (1995), Entorf and Pohlmeier (1990), Blechinger et al. (1997), Smolny (1998, 2002), Van Reenen (1997), Greenan and Guellec (2000), Garcia et al (2002), Peters (2004), Harrison et al (2014), Hall et al. (2009), Lachenmaier and Rottmann (2011), exception: Zimmermann (1991)

- No clear evidence for process innov. (-/0/+), in services mainly no effect
- In manufacturing, no clear evidence whether product or process innovation is more important
- Scarce evidence on employment impacts of green innovation
  - Positive effects of environmental innovations in general
    (Bijman and Nijkamp 1988, Pfeiffer and Rennings 2001, Rennings and Zwick 2002, Harabi 2000, Rennings 2003)
  - Mixed effects of environmental product innovations
    (Horbach 2010, Rennings and Horbach 2013)
  - Seem to be larger compared to other non-environmental innovation
    (Horbach 2010)
  - Cleaner production more likely to increase employment compared to end-of-pipe technologies
    (Pfeiffer and Rennings 2001, Rennings and Zwick 2002)

Empirical Approach

- Extended version of multi-product model by Harrison et al. (2014)
- Basic assumptions:
  - Multi-product approach: Two types of products: old and new products (i=1,2)
  - Firm produces product *i=1* in *t=1* (old product). Output: $Y_{it} = Y_{11}$
  - In *t=2*, a new product (*i=2*) can be introduced which replaces (completely or partially) the old product.

    Output of new product: $Y_{21}=0$, Y_{22}. Output change of old product: $\Delta Y_1=Y_{12}-Y_{11}$
  - Production function:

$$Y_{it} = \theta_{it} F\left(K_{it}, L_{it}, M_{it}\right) e^{\eta+\omega_{it}} \qquad i=1,2; t=1,2$$

    - Non-rival input: knowledge capital, drives efficiency of each process and proportionally raises marginal productivity of *K*, *L, M* by an efficiency parameter θ_{it}.
    - *Efficiency* in the production of the *old product* can increase due to *process innovations, organisational changes*, better skilled personnel, learning effects, etc.

Empirical Approach

- Cost minimization leads to a decomposition of employment growth:

$$\underbrace{l}_{\text{employ-ment growth}} = \underbrace{-\left(\ln\theta_{12}-\ln\theta_{11}\right)}_{\text{Efficiency gain in production of old products (-): } \alpha} + \underbrace{\left(\ln Y_{12}-\ln Y_{11}\right)}_{\text{Rate of change in demand for old products (+/-): } y_1} + \underbrace{\left(\theta_{11}/\theta_{22}\right)\cdot\left(Y_{22}/Y_{11}\right)}_{\text{Starting the production of the new product (+): } \beta * y_2} - \underbrace{\left(\omega_{12}-\omega_{11}\right)}_{\text{Productivity shocks (+/-)}}$$

⇓

i) autonomous increase/ decrease in demand
ii) own cannibalization
iii) business stealing

⇓

depends on efficiency ratio between both technologies: β

- Econometric model:

$$l = \alpha_0 + \alpha_1 pc + y_1 + \beta y_2 + u$$

- Substitute unobserved real output growth rates (y_1, y_2) by observed nominal sales growth rates (g_1, g_2) :

$$l - \left(g_1 - \tilde{\pi}_1\right) = \alpha_0 + \alpha_1 pc + \beta g_2 + controls + v$$

Empirical Approach

- Extension: Differentiating
  - Efficiency gains due to environmental and non-environmental process innovation
  - Sales growth due to new products with and without environmental benefits

$$l-\left(g_1-\tilde{\pi}_1\right)=\alpha_0+\alpha_1 pc_{ENV}+\alpha_2 pc_{NE}+\beta_{ENV} g_{2,ENV}+\beta_{NE} g_{2,NE}+v$$

l	Employment growth rate
$\alpha_0, \alpha_1, \alpha_2$	Efficiency gains in the production of old products unrelated to process innovation (pc) / related to environmental pc / related to non-environmental pc
pc_{ENV} / pc_{NE}	Environmental / non-environmental process innovation (dummy: 0/1)
g_1 / $g_{2,ENV}$ / $g_{2,NE}$	Sales growth rate due to old products / environmental product innovations and non-environmental product innovations
$\tilde{\pi}_1$	Price deflator for old products at an industry level (2-digit)
v	Error term ($v=-E\left(\pi_1-\tilde{\pi}_1\right)-\beta_{ENV}\pi_{2,ENV}y_{2,ENV}-\beta_{NE}\pi_{2,NE}y_{2,NE}+u$)

Data

- European-wide Community Innovation Surveys (CIS)
- Representative straified random samples for all firms with 10+ employees in manufacturing and (almost all) service sectors
- CIS2008: focus on environmental product and process innovation
- Data on 64969 firms from 16 European countries
  - Germany, France, Italy, the Netherlands, Cyprus, Portugal, Malta, Luxemburg, Bulgaria, Czech Republic, Estonia, Hungary, Lithuania, Latvia, Romania, Slovakia each.
- Estimations
  - Pooled
  - Manufacturing and services
  - Countries
  - Sectors – focus of this presentation

	N	%
High-tech	1579	2.43
Medium-tech	17870	27.48
Low-tech	16030	24.65
KIS	12527	19.26
LKIS	17019	26.17

Among this group 30.1% belong to the food industry

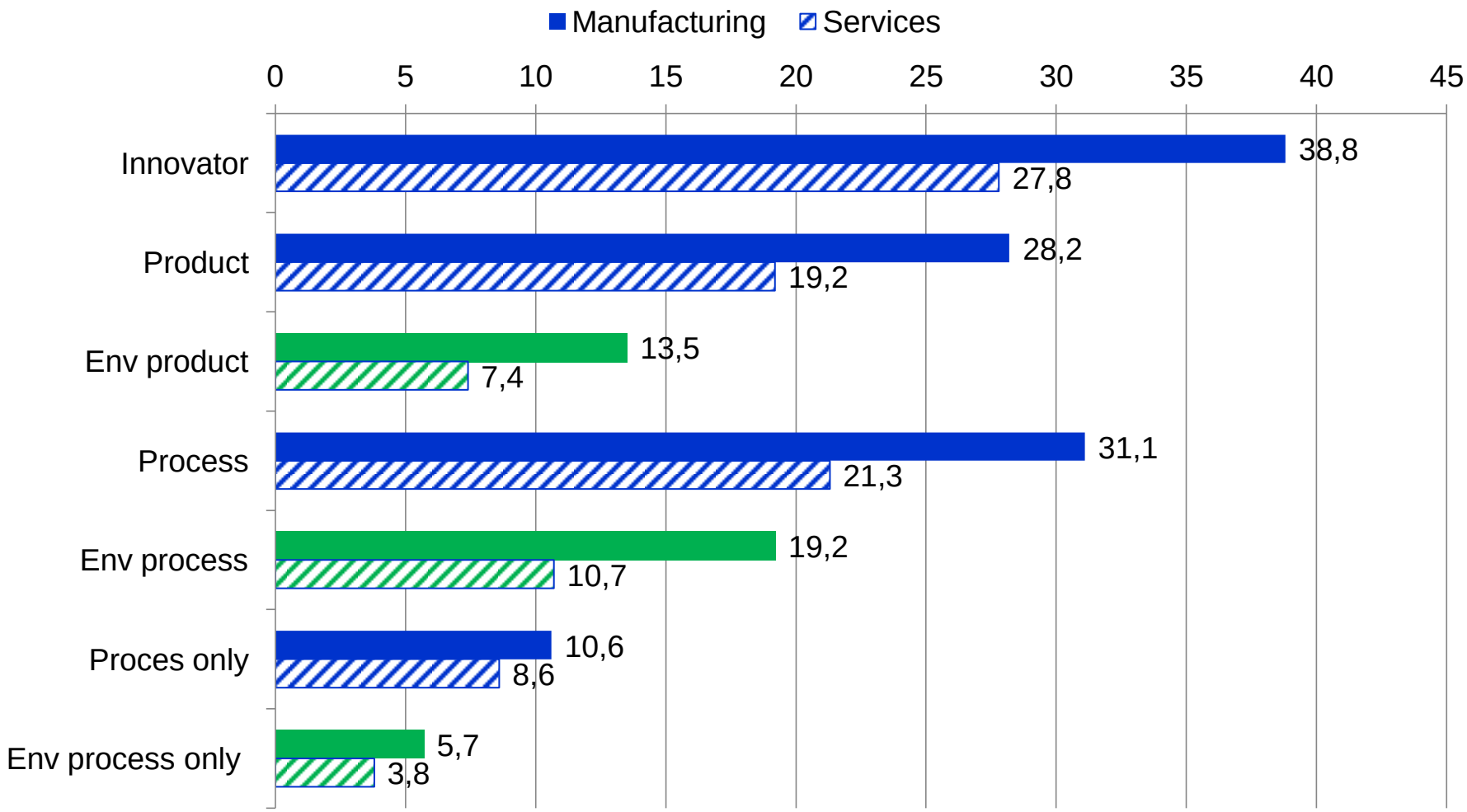
Key Variables

Dependent Variable: $l - g_1 - \tilde{\pi}_1$	
l	**Employment growth rate between 2006 and 2008 (in head counts)**
g_1	**Sales growth due to old products between 2006 and 2008** Computed as total sales growth (g) minus sales growth with new products (g_2)
$\tilde{\pi}_1$	**Price growth rate at industry level between 2006 and 2008**
Explantory variables	
PCONLY	**Process innovation related to old products in 2006-2008 (0/1)** 1 if the firm introduced a new or significantly improved production process, distribution method, or support activity for goods or services, but no product innovation
PCONLY_ENV	**Environmental process innovation (related to old products) in 2006-2008** 1 if firm only introduced process innovations of which at least one had environmental benefits (a reduction in material or energy use per unit of output, a slimming of the CO2 footprint, a cut-back in the air, soil, water or noise pollution, a replacement of dangerous materials or an improved recycling of waste, water and materials)
PCONLY_NE	**Non-environmental process innovation (rel. to old products) in 2006-2008** 1 if the firm introduced at least one process innovation without any environmental benefits.

Key Variables

Explantory variables	
SGR_NEWPD_ENV	**Sales growth rate due to new products between t-2 (2006) and t (2008) for firms that have introduced at least one environmental product innovation.** calculated as share of sales with new products in 2008 * (sales in 2008/sales in 2006) * PD_ENV. PD_ENV: An environmental-friendly product innovation is defined as the introduction of a new product/service that offers environmental benefits to customers through the use of these products/services wrt to reduced energy use, reduced air, water, soil or noise pollution or improved recycling of product after use.
SGR_NEWPD_NE	**Sales growth rate due to new products between t-2 (2006) and t (2008) for firms that have introduced only non-environmental friendly product innovations**

Share of Environmental Innovators



Innovation - Employment Link by Sector

	High-tech		Medium-tech		Low-tech		KIS		LKIS	
Constant	1.504 (4.137)		0.592 (1.886)		2.334 (1.564)		-4.811 (4.736)		1.891 (1.338)	
SGR_NEWPD_ENV	0.984 (0.092)	***	1.033 (0.048)	***	0.977 (0.051)	***	0.959 (0.060)	***	0.919 (0.050)	***
SGR_NEWPD_NE	1.060 (0.103)	***	0.973 (0.059)	***	0.984 (0.062)	***	0.902 (0.042)	***	1.078 (0.083)	***
PCONLY_ENV	4.049 (3.773)		-0.248 (1.335)		-1.584 (1.287)		2.118 (1.963)		-1.587 (1.567)	
PCONLY_NE	-6.536 (5.047)		-4.084 (1.930)	**	-3.746 (1.781)	**	-0.698 (2.024)		0.825 (2.092)	
R2_adj	0.557		0.451		0.407		0.358		0.331	
Wald-Test: $\beta_{ENV}=1$	0.858		0.500		0.651		0.489		0.104	
Wald-Test: $\beta_{NE}=1$	0.563		0.642		0.795		0.021	**	0.346	
PCONLY: ENV=NE	0.076	*	0.080	*	0.294		0.295		0.330	
SGR_NEWPD: ENV=NE	0.604		0.480		0.941		0.508		0.154	
Tests on Exogeneity										
SGR_NEWPD_ENV&NE	0.014	**	0.000	***	0.014	**	0.000	***	0.000	***
Tests on instr. Validity										
Sargan/Hansen J-Test	0.877		0.521		0.393		0.522		0.880	
F-stat SGR_NEWPD_ENV	25.53	***	83.65	***	82.80	***	74.03	***	61.99	***
F-stat SGR_NEWPD_NE	21.75	***	50.86	***	92.52	***	165.36	***	45.59	***
Test on weak inst.										
Cragg-Donald F test	51.29	***	375.42	***	302.03	***	240.57	***	344.39	***
Kleibergen-Paap F test	22.37	***	44.20	***	39.26	***	38.08	***	27.27	***
Number of obs	1579		17870		16030		12527		17019	

Additionally included but not reported: country, industry (2-digit), size and ownership dummies
Estimation method: IV, instruments: RANGE, R&D, CLIENT, ENVREG, ENVAGREE

Key Findings

- **New products of environmental product innovators stimulate employment growth in *all* sectors**
  - In High-, Medium-, Low-tech and LKIS: coefficient of 1
    - A one-percent increase in the sales due to new products also increases *gross* employment by one percent
    - Implies that old and new products of environmental product innovators are produced with the same efficiency (no productivity effects of new products)
  - Environmental PD are produced with higher efficiency in KIS
- **New products of non-environmental product innovators stimulate employment growth in *all* sectors**
  - Coefficient is not significantly different from 1 implying that old and new products of non-environmental product innovators are produced with the same efficiency

Key Findings

- **No employment effects of environmental process innovation**
  - Negative displacement and positive compensation effects outweigh each other
- **Weak evidence of labour displacement of non-environmental process innovation**
  - Effect is negative in majority of sectors (labour displacement) though only significant in Medium- and Low-tech

Quantitative Contribution of Innovation to Employment Growth: A Decomposition

- Based on estimation, average employment growth can be decomposed into

$$l = \underbrace{\hat{\alpha}_{0,IS}}_{1} + \underbrace{\hat{\alpha}_1 pc_{ENV}}_{2a} + \underbrace{\hat{\alpha}_2 pc_{NE}}_{2b} + \underbrace{\left[1 - I\left(g_{2,ENV} > 0 \cup g_{2,NE} > 0\right)\right]\left(g_1 - \tilde{\pi}_1\right)}_{3}$$
$$+ \underbrace{I\left(g_{2,ENV} > 0\right)\left(g_1 - \tilde{\pi}_1 + \hat{\beta}_{ENV} g_{2,ENV}\right)}_{4a} + \underbrace{I\left(g_{2,NE} > 0\right)\left(g_1 - \tilde{\pi}_1 + \hat{\beta}_{NE} g_{2,NE}\right)}_{4b} + \hat{v}$$

1: General productivity trend in production of old products (industry & size specific)

2: Displacement effect of process innovation related to old products
- for environmental process innovation (2a)
- for non-environmental process innovation (2b)

3: Output growth due to old products (for non-product innovators)

4: Net contribution of product innovation
- for environmental product innovators (4a)
- for non-environmental product innovators (4b)

➔ increases in demand for new products and (positive or negative) shift in demand for the old product

Decomposition of Employment Growth

	High	Medium	Low	KIS	LKIS
Employment growth	**6.5**	**5.6**	**3.2**	**11.1**	**8.8**
Decomposed into					
(1) General productivity trend in production of old products	**-15.2**	**-7.2**	**-4.4**	**-6.4**	**-5.0**
(2) Gross effect of process innovations related to old products	**0.0**	**-0.2**	**-0.3**	**0.1**	**-0.1**
(2a) ***environmental process*** innovations	**0.2**	**0.0**	**-0.1**	**0.1**	**-0.1**
(2b) ***non-environmental process*** innovation	**-0.2**	**-0.2**	**-0.2**	**0.0**	**0.0**
(3) Output growth of old products for non-product innovators	**9.4**	**8.7**	**6.0**	**12.1**	**11.6**
(4) Net contribution of product innovations	**12.4**	**4.2**	**1.9**	**5.4**	**2.2**
(4a) output reduction in old products	**-8.4**	**-6.4**	**-5.3**	**-4.8**	**-3.4**
(4b) output increase in new products ***for environmental pd***	**9.7**	**5.5**	**3.0**	**3.2**	**2.5**
(4c) output increase in new products ***for non-environmental pd***	**11.1**	**5.1**	**4.1**	**7.0**	**3.1**

Key Findings

- **Net contribution of product innovation to employment growth is positive and sizable in all sectors.**
  - Range of 2 to 5%, with a much larger impact in High-Tech.
  - Both environmental and non-environmental product innovators have contributed to a considerable amount to employment growth.
    - Non-environmental product innovators contributed more to employment growth than environmental product innovators, exception: Medium-tech
    - Observed differences in the contribution of environmental and non-environmental product innovation to employment growth are mainly a result of differences in the average innovation engagement and innovation success across sectors,
    - but not by differences in the transformation of a given level of innovation success to employment growth.
- But product innovations have contributed less to employment growth than old products in all sectors except for High-tech.
- Contribution of both environmental and non-environmental process innovation is rather small in terms of magnitude.

Policy Conclusions

- From the perspective of generating smart and sustainable (employment) growth, policy should stimulate both types of product innovation.
- A stronger focus of environmental-friendly product innovation compared to non-environmental-friendly product innovation will most likely not have different employment impacts
  - Estimated gross employment effect of product innovation for both types of product innovators are very similar in nearly all sectors and countries.
  - Observed differences in the contribution of both types of product innovation across countries are thus a result of differences in the average innovation engagement and innovation success across countries, but not of differences in the transformation of a given level of innovation success to employment growth.
  - Assuming no structural breaks, this opens up similar employment potentials across sectors/countries if policy is successful in stimulating environmental innovation.
- No significant trade-off between more environmental-friendly production technologies and employment growth. From that result we might also infer that there is no trade-off between employment growth and stricter environmental regulations (in different fields).

Thank you for your attention!

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