

# Innovation, Productivity, and Training

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## Haelermans and Borghans (BJIR, 2012)

A recent meta-analysis of 71 sets of results from 38 studies shows an average wage increase of 2.6% for each training episode

## Dostie (JHC, 2013)

Using value-added per worker as a measure of productivity at the firm level, Dostie (2013) finds that employees who undertook classroom training are 3.4% more productive while those who undertook on-the-job training produce on average 1.6% more value added

# Should we expect a link between training and innovation?

## Bauernshuster, Falck and Heblich (JHC, 2009)

Bauernshuster, Falck and Heblich (2009) argue that continuous training guarantees access to leading-edge knowledge and thus increase a firm's propensity to innovate.

## Should we expect a link between training and innovation?

- Innovation Canada: A Call to Action. A Review of Federal Support to Research and Development - Expert Panel Report 2011.
- Innovation and Business Strategy: Why Canada Falls Short. The Expert Panel on Business Innovation (2009).

- Germany: Bauernschuster and al (JHC, 2009) find a strong association between continuous training and innovation. A 10 percentage-point increase in training intensity translates into a 10 percentage-point higher propensity to innovate.
- Spain: Gonzales and al (2012) find that worker training has a significant effect on firm innovation performance.
- France: Gallié and Legros (Empirical Economics, 2012) find significant effects of R&D intensity and training on patenting activities.

- We use the Workplace and employee survey 1999-2006
- WES includes detailed measures of innovation and training at the establishment level.
- WES distinguishes between on-the-job and classroom training.
- WES distinguishes product/services and process innovation, radical or routine innovation.

**Table :** Survey Design

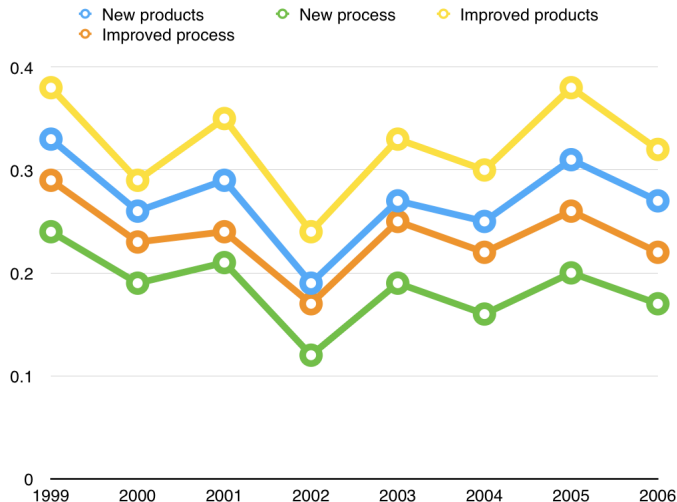
Year	Workplaces	Workers
1999	6,322	23,540
2000	6,068	20,167
2001	6,207	20,352
2002	5,818	16,813
2003	6,565	20,834
2004	6,159	16,804
2005	6,693	24,197
2006	6,312	



- New processes include the adoption of new methods of goods production or service delivery.
- Improved processes are those whose performance has been significantly enhanced or upgraded.
- New goods or services differ significantly in character or intended use from previously produced goods or services.
- Improved goods or services are those whose performance has been significantly enhanced or upgraded.

- Zeytinoglu and Cooke (Journal of Industrial Relations (2009)) use WES 2001. Multivariate results show that innovation introduced in the workplace is significantly associated with providing on-the-job training.
- Walsworth and Verma (Journal of Industrial Relations (2007)) use WES 1999-2002. Find that autonomy training has a positive relationship with innovation.

# Percentage of workplaces reporting innovation depending on training status



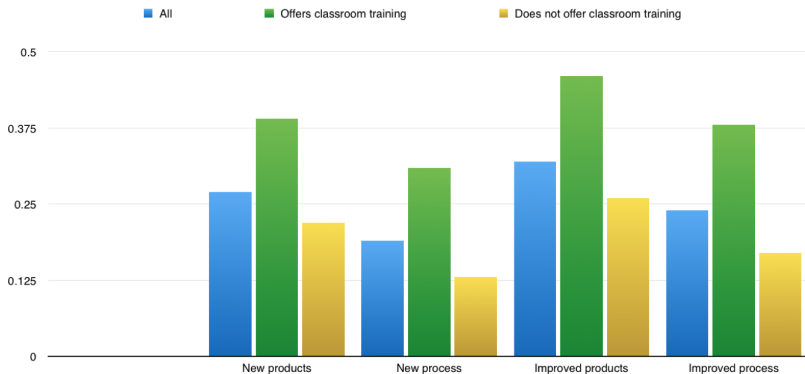
# New (improved) processes

		Process innovation			
On-the-job Training		1999	2001	2003	2005
	No	20%	18%	16%	17%
	Yes	46%	38%	39%	38%
Classroom Training					
	No	23%	20%	20%	20%
	Yes	50%	43%	41%	41%
Total		32%	27%	27%	28%

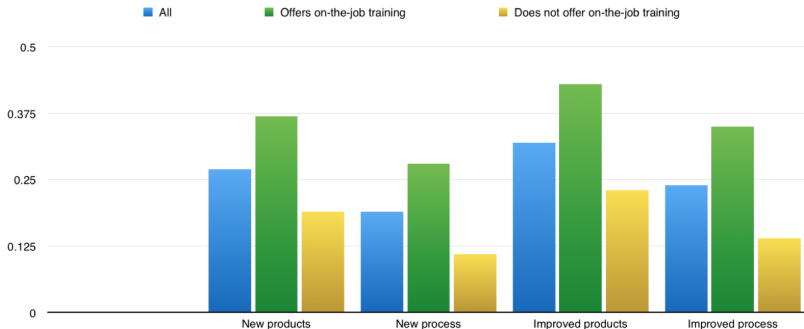
# New (improved) products or services?

		Product innovation			
On-the-job Training		1999	2001	2003	2005
	No	34%	29%	27%	29%
	Yes	58%	50%	48%	54%
Classroom Training					
	No	37%	32%	31%	35%
	Yes	61%	54%	49%	54%
Total		44%	39%	37%	42%

# Percentage of workplaces reporting innovation depending on training status



# Percentage of workplaces reporting innovation depending on training status



# Classroom training intensities

		Process Innovation		Product/services Innovation	
		No	Yes	No	Yes
On-the-job training intensity					
	1999	23%	44%	22%	40%
	2001	27%	52%	26%	45%
	2003	28%	53%	27%	48%
	2005	27%	52%	24%	48%



# On-the-job training intensities

		Process Innovation		Product/services Innovation	
		No	Yes	No	Yes
Classroom training intensity					
	1999	15%	30%	14%	27%
	2001	17%	34%	15%	31%
	2003	19%	35%	18%	33%
	2005	19%	33%	18%	29%

$$P(\textit{Innovation} = 1)_{jt} = \alpha + \rho \textit{Training}_{jt} + \beta X_{jt} + \epsilon_{jt}$$

- Technology use
- Proportion of workers covered by a collective bargaining agreement
- Occupational structure of the workplace
- Firm Size + Industry + Year Controls

# OLS results

	Product		Process	
	New	Improved	New	Improved
Classroom training intensity	0.131*** (0.003)	0.137*** (0.010)	0.125*** (0.006)	0.137** (0.019)
On-the-job training intensity	0.164*** (0.005)	0.177*** (0.002)	0.159*** (0.008)	0.191*** (0.014)
<i>Workforce characteristics</i>				
Prop. of empl. using a computer	0.093** (0.013)	0.091** (0.012)	0.070*** (0.002)	0.088*** (0.005)
Prop. of empl. covered by a CBA	0.020*** (0.002)	0.025 (0.020)	-0.003 (0.006)	0.022 (0.010)
Prop. of managers	0.044*** (0.004)	0.024 (0.010)	0.032 (0.021)	0.024 (0.015)
<i>Firm Size</i>				
1-19 employees	- -	- -	- -	- -
20-99 employees	0.077*** (0.007)	0.099** (0.012)	0.086*** (0.007)	0.109*** (0.004)
100-499 employees	0.093*** (0.007)	0.133*** (0.010)	0.186*** (0.016)	0.190*** (0.009)
500 employees and more	0.150** (0.034)	0.164** (0.036)	0.233** (0.050)	0.239*** (0.017)
Constant	0.031 (0.016)	0.087*** (0.005)	0.040 (0.018)	0.071* (0.018)
# observations	43476	43476	43476	43476
R-squared	0.10	0.09	0.10	0.11

Bootstrapped standard errors in parentheses

\* significant at 10%; \*\* significant at 5%; \*\*\* significant at 1%

Includes year (8) and industry dummies (14)

TABLE 5. Linear probability model: OLS coefficient estimates

	Product		Process	
	New	Improved	New	Improved
Classroom training intensity	0.131*** (0.003)	0.137*** (0.010)	0.125*** (0.006)	0.137** (0.019)
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$$P(\textit{Innovation} = 1)_{jt} = \alpha + \rho \textit{Training}_{jt} + \beta X_{jt} + \psi_j + \epsilon_{jt}$$

# Workplace FE results

	Product		Process	
	New	Improved	New	Improved
Classroom training intensity	0.073*** (0.005)	0.074** (0.012)	0.054** (0.007)	0.078** (0.014)
On-the-job training intensity	0.066** (0.011)	0.086** (0.009)	0.092** (0.010)	0.112** (0.012)
<i>Workforce characteristics</i>				
Proportion of employees using a computer	0.037 (0.013)	0.036** (0.007)	0.034*** (0.002)	0.050*** (0.002)
Proportion of employees covered by a CBA	0.006 (0.026)	0.040** (0.008)	-0.034 (0.021)	-0.006 (0.040)
Proportion of managers	0.028 (0.015)	0.006** (0.001)	0.040 (0.022)	0.036** (0.008)
<i>Firm Size</i>				
1-19 employees	- -	- -	- -	- -
20-99 employees	0.035 (0.019)	0.028** (0.004)	-0.016 (0.010)	0.014 (0.021)
100-499 employees	0.064 (0.039)	0.036 (0.027)	0.059 (0.031)	0.064 (0.032)
500 employees and more	0.062 (0.032)	0.061** (0.012)	-0.001 (0.011)	0.019 (0.017)
# observations	43476	43476	43476	43476
R-squared	0.02	0.03	0.03	0.03

Bootstrapped standard errors in parentheses

\* significant at 10%; \*\* significant at 5%; \*\*\* significant at 1%

Includes year (8) and industry dummies (14)

TABLE 6. Linear probability model: FE coefficient estimates

	Product		Process	
	New	Improved	New	Improved
Classroom training intensity	0.073*** (0.005)	0.074** (0.012)	0.054** (0.007)	0.078** (0.014)
On-the-job training intensity	0.066** (0.011)	0.086** (0.009)	0.092** (0.010)	0.112** (0.012)
<i>Workforce characteristics</i>				
Proportion of employees using a computer	0.037 (0.013)	0.036** (0.007)	0.034*** (0.002)	0.050*** (0.002)
Proportion of employees covered by a CRA	0.006 (0.006)	0.040** (0.008)	-0.034 (0.021)	-0.006 (0.040)



$$P(\text{Innovation} = 1)_{jt} = \alpha + \rho \text{Training}_{jt} + \beta X_{jt} + \psi_j + \eta_{jt} + \epsilon_{jt}$$

TABLE 7. Linear probability model: GMM coefficient estimates

	Product		Process	
	New	Improved	New	Improved
Classroom training intensity	0.046*** (0.012)	0.071*** (0.013)	0.062*** (0.012)	0.071*** (0.012)
On-the-job training intensity	0.061*** (0.011)	0.057*** (0.012)	0.081*** (0.011)	0.070*** (0.011)
$\alpha$	0.126*** (0.034)	0.106*** (0.033)	0.126*** (0.032)	0.064*** (0.031)
# observations	27287	27287	27287	27287

Standard errors in parentheses

\* significant at 10%; \*\* significant at 5%; \*\*\* significant at 1%

Includes year (8) and industry dummies (14)

Increases in firm-sponsored on-the-job and classroom training lead to more innovation.

TABLE 9. Coefficient estimates: production function, reduced form model

	(1)	(2)	(3)
ln(no. employees)	0.972*** (0.010)	0.965*** (0.011)	0.964*** (0.012)
Classroom training intensity	0.123*** (0.023)	0.095*** (0.022)	0.074*** (0.021)
On-the-job training intensity	-0.032* (0.017)	-0.011 (0.017)	-0.012 (0.023)
<i>Innovation (t)</i>			
new product	0.005 (0.035)	0.014 (0.042)	0.018 (0.042)
improved product	-0.042 (0.034)	-0.082** (0.039)	-0.091** (0.042)
new process	-0.042 (0.040)	-0.053 (0.045)	-0.058 (0.049)
improved process	0.086** (0.040)	0.105** (0.043)	0.101** (0.048)

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improved product	-0.042 (0.034)	-0.082** (0.039)	-0.091** (0.042)
new process	-0.042 (0.040)	-0.053 (0.045)	-0.058 (0.049)
improved process	0.086** (0.040)	0.105** (0.043)	0.101** (0.048)

# Innovation and Productivity\*\*\*

	(0.040)	(0.043)	(0.048)
<i>Innovation (t-1)</i>			
new product	0.040 (0.038)	0.074* (0.052)	
improved product	-0.045 (0.039)	-0.065 (0.043)	
new process	-0.065 (0.047)	-0.056 (0.050)	
improved process	0.104** (0.046)	0.113** (0.043)	
<i>Innovation (t-2)</i>			

# Innovation and Productivity\*\*\*

<i>Innovation (t-2)</i>			
new product			0.011 (0.041)
improved product			-0.069* (0.042)
new process			-0.049 (0.054)
improved process			0.115** (0.053)
Constant	11.018*** (0.062)	11.055*** (0.076)	10.994*** (0.080)
Observations	41563	32761	24943
R-squared	0.61	0.62	0.64

Standard errors in parentheses

\* significant at 10%; \*\* significant at 5%; \*\*\* significant at 1%

Includes workforce characteristics, workplace size (4),  
year (8) and industry dummies (14)

Improved process innovation seems to have a big and long-lasting impact on productivity.



TABLE 10. Coefficient estimates: production function, joint model

	log(value added)	Improved process
ln(no. employees)	0.922 (0.007)	- -
Classroom training intensity	0.132 (0.02)	0.103 (0.008)
On-the-job training intensity	-0.147 (0.019)	0.177 (0.008)
Improved process	0.285 (0.059)	
Strategy1		0.137 (0.007)
Strategy2		0.094 (0.006)

Constant	0.113 (0.023)	0.005 (0.03)
$\sigma_\epsilon$	0.675 (0.004)	0.377 (0.004)
$\rho_\epsilon$	-0.126 (0.034)	
$\sigma_u$	0.675 (0.006)	0.142 (0.005)
$\rho_u$	-0.049 (0.03)	
Observations	21,440	
Log-lik	-4295634.165	

Standard errors in parentheses

\* significant at 10%; \*\* significant at 5%; \*\*\* significant at 1%

Includes workforce characteristics, workplace size (4),  
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Improved process	0.285 (0.059)	
Strategy1		0.137 (0.007)
Strategy2		0.094 (0.006)

On-the-job training seems to have an impact on productivity through improved process innovation.

- Impact of training on innovation very robust.
- On-the-job training's role as important as classroom training.
- Improved process innovation seems to have a big impact on productivity.
- On-the-job training seems to have an impact on productivity through improved process innovation.