Competition and Innovation in Luxembourg
A Dynamic Panel Data Analysis

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What, why and how?

What?

The analysis revisits the competition-innovation relationship using a panel of enterprise data stemming from various waves of the Luxembourgish innovation survey and pertaining to the period 2002-2010

Why?

- Small and open economy
- International competition likely to be fierce
- Innovation and competitiveness among priorities for Luxembourg

How?

- Nonlinear dynamic simultaneous-equations model
  - full-information maximum likelihood
  - average partial effects
- Unbalanced panel data

Literature

Schumpeterian effect

Competitive markets are not necessarily the most effective organizations to promote innovation

Arrowian effect

There is a greater incentive to innovate in more competitive environments

Inverted-U relationship

- Arrowian (escape-competition) effect when initial competition is low
- Schumpeterian effect when initial competition is high

Contributions

Perceived competition

- market concentration variables, e.g. Herfindhal index
- price-cost margin or Lerner index
- profit elasticity or Boone index

Structural modeling

We go beyond the sole innovation input

Dynamic modeling

- sunk costs
- success breeds success

Policy recommendations

We aim to assist policy makers in Luxembourg in targeting the "right" firms when encouraging innovation under more fierce competition

Data

Source

Community Innovation Survey pertaining to 2002-2010
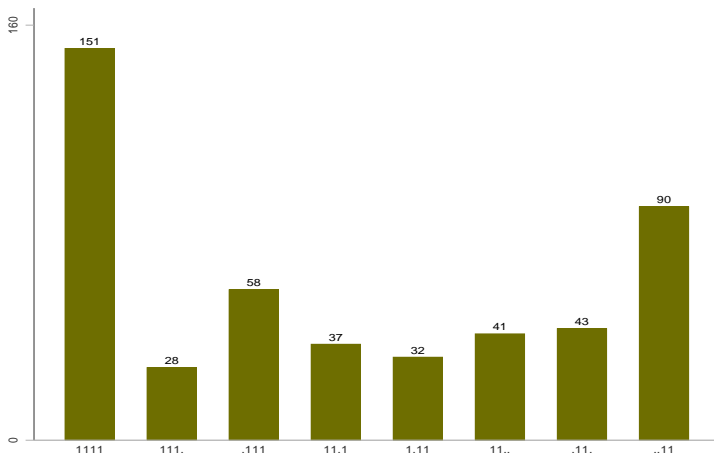
Perceived competition

- PC 1: arrival of new competitors
- PC 2: rapidly changing technologies
- PC 3: outdated products (goods or services)
- PC 4: easy substitution of products

Technological innovation

- Innovation spending
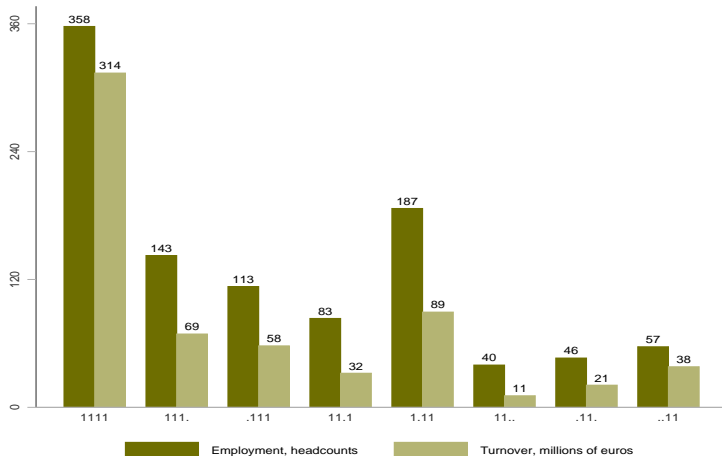- Product innovation
- Process innovation
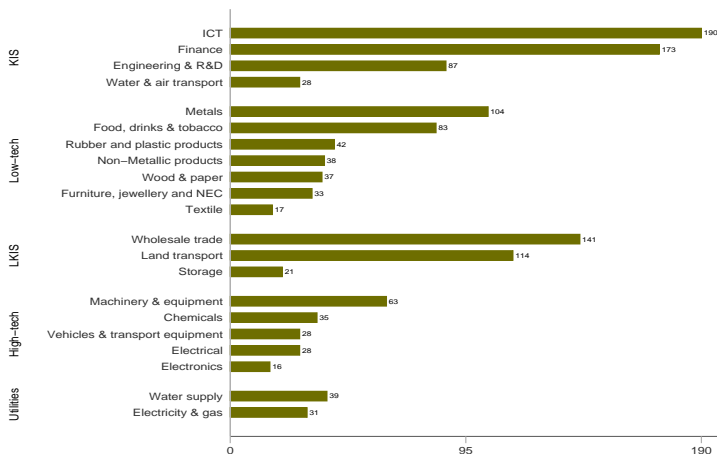
Unbalanced panel
Number of enterprises

Unbalanced panel
Size in sub-categories

Unbalanced panel
Number of observations by industry

Descriptive statistics
Competition and innovation by industry

Sector	Perceived competition				Innovation		
	PC 1	PC 2	PC 3	PC 4	Spending	Product	Process
Manufacturing	0.64	0.56	0.47	0.70	0.58	0.48	0.42
Low-tech	0.66	0.51	0.44	0.68	0.47	0.39	0.39
High-tech	0.63	0.65	0.53	0.75	0.82	0.66	0.49
Services	0.62	0.56	0.53	0.63	0.50	0.46	0.40
LKIS[‡]	0.70	0.51	0.48	0.63	0.32	0.28	0.29
KIS[‡]	0.58	0.59	0.57	0.64	0.61	0.57	0.46
Utilities	0.47	0.32	0.26	0.45	0.37	0.26	0.26
Whole sample	0.62	0.55	0.50	0.65	0.53	0.46	0.40
# observations	1017				1348		

The perceived competition variables are available only in the first three waves of the CIS.

[‡]KIS and LKIS mean respectively knowledge- and less knowledge-intensive services.

Descriptive statistics
Competition and innovation by CIS

CIS	# firms	Perceived competition				Innovation		
		PC 1	PC 2	PC 3	PC 4	Spending	Product	Process
02-2004	257	0.62	0.54	0.42	0.75	0.61	0.47	0.44
04-2006	358	0.65	0.59	0.66	0.46	0.54	0.49	0.36
06-2008	402	0.60	0.51	0.40	0.75	0.48	0.42	0.45
08-2010	331	-	-	-	-	0.50	0.46	0.36

Descriptive statistics
Control variables

Variable	Mean	Median	Std. Dev.	Min.	Max.
Conglomerate status					
Independent	0.417	-	-	0	1
Local conglomerate	0.222	-	-	0	1
Multinational	0.361	-	-	0	1
Employment, headcounts	211	70	509	10	6491
Univ. degree of emp.					
$<5\%$	0.253	-	-	0	1
$[5\%, 50\%]$	0.465	-	-	0	1
$>50\%$	0.282	-	-	0	1
Subsidies					
all firms	0.180	-	-	0	1
innovative firms	0.335	-	-	0	1

Relation between competition and innovation
Tetrachoric correlations

	Competition				Innovation		
	PC 1	PC 2	PC 3	PC 4	Spending	Product	Process
Competition							
PC 1	1						
PC 2	0.17^{**}	1					
PC 3	0.18^{**}	0.73^{**}	1				
PC 4	0.33^{**}	0.18^{**}	$0.10^{\dagger}$	1			
Innovation							
Spending	0.05	0.28^{**}	0.30^{**}	0.08	1		
Product	0.04	0.22^{**}	0.22^{**}	0.14^{*}	0.87^{**}	1	
Process	0.04	0.19^{**}	0.22^{**}	0.06	0.80^{**}	0.60^{**}	1

Significance levels : $\dagger$: 10% $*$: 5% $**$: 1%

Model

Nonlinear Dynamic Simultaneous Equations

$$spend_{it} = \mathbb{1}[\gamma_1 spend_{i,t-1} + \boldsymbol{\beta}'\mathbf{compet}_{i,t-1} + \boldsymbol{\delta}_1'\mathbf{x}_{it} + \epsilon_{1it} > 0] \qquad (1)$$

$$prod_{it} = \mathbb{1}[\gamma_2 prod_{i,t-1} + \vartheta spend_{it} + \boldsymbol{\delta}_2'\mathbf{z}_{it} + \epsilon_{2it} > 0] \qquad (2)$$

$$proc_{it} = \mathbb{1}[\gamma_3 proc_{i,t-1} + \lambda spend_{it} + \boldsymbol{\delta}_3'\mathbf{z}_{it} + \epsilon_{3it} > 0] \qquad (3)$$

Pseudo fixed-effects

$$\epsilon_{kit} = \alpha_{ki} + \mu_{kt} + \nu_{kit}, \qquad k \in \{1,2,3\}, \qquad (4)$$

$$\alpha_{ki} \simeq \sum_{j=1}^{J} \alpha_{kj} D_i^j; \ \mu_{kt} = \sum_{s=2}^{T} \mu_{ks} D_t^s, \qquad (5)$$

$$D_i^j = \left\{ \begin{array}{ll} 1 & \text{if } i \in j \\ 0 & \text{if } i \notin j \end{array} \right. ; \ D_t^s = \left\{ \begin{array}{ll} 1 & \text{if } s = t \\ 0 & \text{if } s \neq t \end{array} \right. . \qquad (6)$$

Estimation

Full-information maximum likelihood

$$\boldsymbol{\nu} | regressors, D_i^j, D_t^s \sim \mathbf{N} \left[\mathbf{0}, \boldsymbol{\Sigma} = \begin{pmatrix} 1 \\ \rho_{12} & 1 \\ \rho_{13} & \rho_{23} & 1 \end{pmatrix} \right]$$

$$\ln L = \sum\nolimits_{000} \ln L_{000} + ... + \sum\nolimits_{111} \ln L_{111} \qquad (7)$$

Average partial effects

- Nonlinear conditional means
- APEs
  - direct
  - indirect
  - total

- Expressions involve law of iterated expectations

The role of perceived competition 1
Rapidly changing technologies

Variable	$Spending_t$		$Product_t$		$Process_t$	
	APE	Std. Err.	APE	Std. Err.	APE	Std. Err.
$Competition_{t-1}$						
CP 1	0.005	0.030	0.003	0.020	0.003	0.019
CP 2	0.068^*	0.029	0.045^*	0.020	0.042^*	0.019
CP 4	-0.009	0.031	-0.006	0.020	-0.005	0.019
Industry			yes			
Time			yes			
Log-likelihood			-1139.087			
# observations			868			

Significance levels :   † : 10%   ∗ : 5%   ∗∗ : 1%

The role of perceived competition 2
Outdated products

Variable	Spending$_t$		Product$_t$		Process$_t$	
	APE	Std. Err.	APE	Std. Err.	APE	Std. Err.
Competition$_{t-1}$						
CP 1	0.002	0.030	0.001	0.019	0.001	0.018
CP 2	0.018	0.033	0.012	0.022	0.011	0.021
CP 3	0.103**	0.035	0.068**	0.023	0.065**	0.022
CP 4	-0.015	0.031	-0.010	0.020	-0.009	0.019
Industry			yes			
Time			yes			
Log-likelihood			-1134.506			
# observations			868			

Significance levels :   † : 10%   ∗ : 5%   ∗∗ : 1%

Dynamics of innovation

Variable	Spending$_t$		Product$_t$		Process$_t$	
	APE	Std. Err.	APE	Std. Err.	APE	Std. Err.
Spending$_t$	-	-	0.655**	0.050	0.625**	0.041
Spending$_{t-1}$	0.262**	0.039	0.173**	0.028	0.164**	0.027
Product$_{t-1}$	-	-	0.106**	0.028	-	-
Process$_{t-1}$	-	-	-	-	0.048†	0.026
Industry			yes			
Time			yes			
Log-likelihood			-1134.506			
# observations			868			

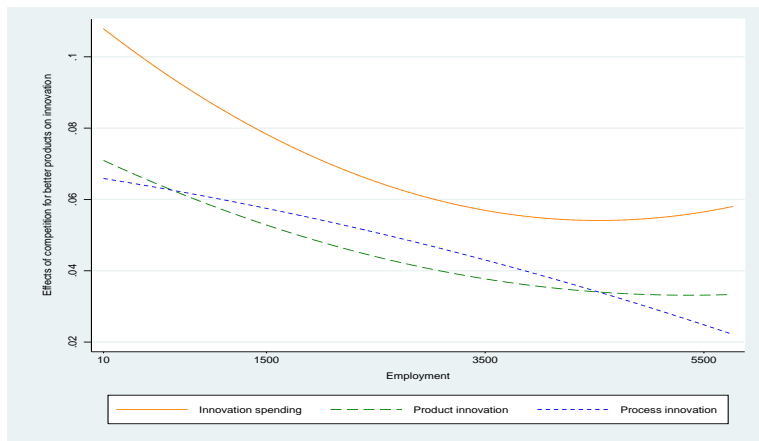Significance levels : $\dagger$: 10% $*$: 5% $**$: 1%

Partial effects of competition versus employment

Rapidly changing technologies
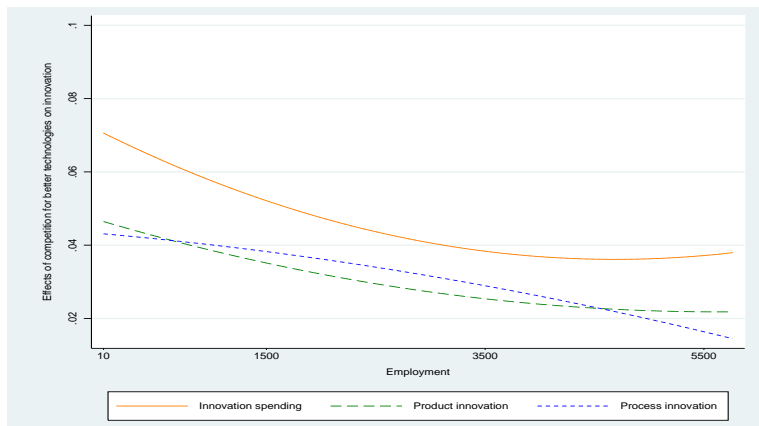
Partial effects of competition versus employment
Outdated products

Summary

- PC 2 Granger-causes innovation if PC 3 is excluded
- PC 3 Granger-causes innovation when all PC measures are included
- PC 1 and PC 4 are insignificant
- Effect of PC 2 and PC 3 decreases with firm size
- Persistence of innovation decreases with firm size
- Effect of perceived competition is low in high-tech sector
  - high competition is observed
  - high level of innovation is observed
- Effect of perceived competition is high in utilities sector
  - low competition is observed
  - low innovation is observed