Innovation, Productivity and Exports. The Hungarian case

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Motivation

- Relationship between innovative inputs, outputs and firm performance
- Contributions
  - First analysis on Hungary
  - Different measures of performance
    - Labour productivity
    - TFP
    - Export performance
  - Heterogeneity between foreign and domestic firms
  - Public policy

Outline

- Data and methodology
- Base model results
- Heterogeneity
  - Foreign firms
- Innovation and exports

Data

- Hungarian firm-level Community Innovation Survey data from 2003 and 2006, and annual R&D survey data;
- CIS data can be merged with balance sheet data;
- Balance sheet data is a large annual firm-level panel, suitable for the estimation of different performance measures;
- Matched with detailed trade data (product, destination/origin, firm)

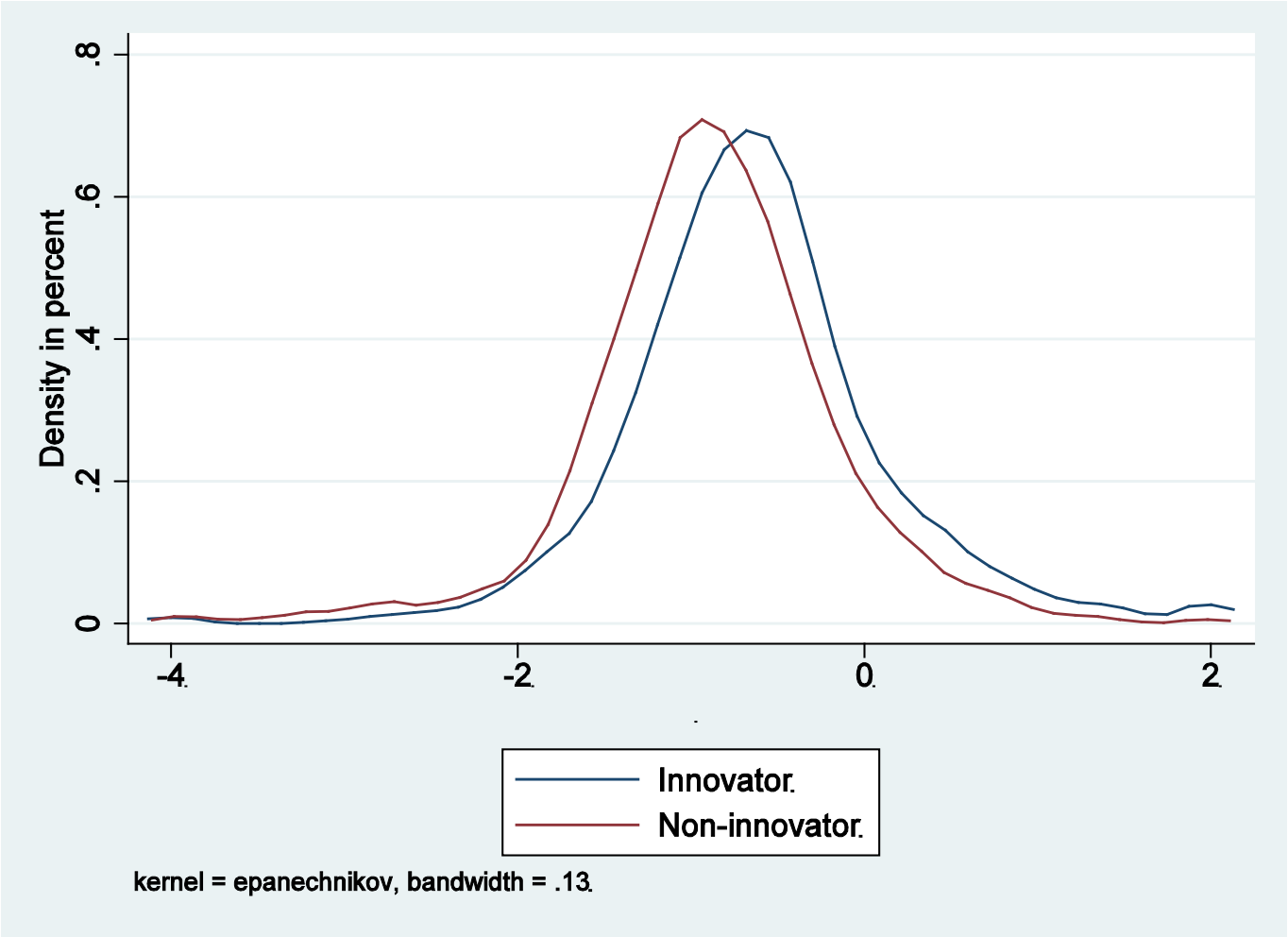
Sample

	Total sample	Merged
Observations	6514	3619
Employees		
1-49	30.9	23.2
50-99	17.0	14.3
100-249	23.1	30.1
250-1000	18.3	27.1
>1000	10.7	5.3
Innovation		
Continuous R&D	7.6	9.0
Product innovation	21.5	25.4
Process innovation	20.7	24.6

Innovation: inputs and outputs

	France	Germany	Spain	UK	HU 2004	HU 2006
Knowledge/innovation						
Continuous R&D engagement %	35.0	39.5	20.9	26.7	10.6	9.8
Log(R&D/employee) (continuous R&D engagement)	6.9	5.2	4.3	3.6	4.8	4.9
Innovator (product and/or process innovation) %	52.9	65.8	51.2	41.5	32.7	31.7
Process innovation %	32.3	42.3	34.7	27.1	21.5	20.1
Product innovation %	44.6	54.7	33.6	28.6	22.4	20.8
Share of sales with new products (firms with product innovation) %	16.5	29.5	32.7	30.8	25.7	23.9

Differences in productivity



Structure

(i) Decision on R&D investment;

(ii) Intensity of R&D investment;

(iii) Innovation production - process or product;

(iv) Performance (productivity, export) function, where innovation is an input

Methodology

- Following Crépon, Duguet and Mairesse (CDM) (1998) and Griffith, Huergo, Mairesse and Peters (GHMP) (2006)
  - It is widely used in the literature (e.g. van Leeuwen at al, 2008, Robin and Mairesse, 2008, Peters, 2008, Mairesse et al, 2009)
- Separate estimation of a system of equations:
  - R&D intensity - Heckman or Generalised Tobit
  - Knowledge production function - Biprobit model for product- and process innovation
  - Output production function - labour productivity

Econometric problems and their solutions in the CDM model

- Endogeneity and simultaneity of R&D and innovation
  - Step-by-step estimation, instrumenting R&D and innovative output from earlier steps
- Selection: only firms with higher expected return conduct R&D
  - Estimating the R&D intensity equation with generalised tobit
- R&D is only a noisy proxy for innovative input
  - Instrumented R&D input is used, knowledge- and output production functions are estimated for all firms
- More issues considered
  - Collinearity between different types of innovation

R&D selection

VARIABLES	(1) Selection
International competition	0.038***
Formal protection	0.064***
Average wage: 2nd quartile	-0.079
Average wage: 3rd quartile	0.310
Average wage: 4th quartile	0.486**
Subsidy from municipality	0.052
Subsidy from government	0.120***
Subsidy from EU	0.109***
Size: 50–99	0.051***
Size: 100–249	0.086***
Size: >250	0.128***
Observations	3,619
Industry dummies	Yes
Demand pull variables	No
Information source variables	No
rho	0.819
ln likelihood	-1430

Bootstrapped standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

R&D selection and intensity

VARIABLES	(1) Selection	(2) R&D intensity
International competition	0.038***	1.610***
Formal protection	0.064***	1.176***
Average wage: 2nd quartile	-0.079	1.401
Average wage: 3rd quartile	0.310	1.217
Average wage: 4th quartile	0.486**	2.146**
Subsidy from municipality	0.052	0.283
Subsidy from government	0.120***	1.014***
Subsidy from EU	0.109***	1.226***
Size: 50–99	0.051***	
Size: 100–249	0.086***	
Size: >250	0.128***	
Observations	3,619	3,619
Industry dummies	Yes	Yes
Demand pull variables	No	Yes
Information source variables	No	Yes
rho	0.819	0.819
ln likelihood	-1430	-1430

Bootstrapped standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Knowledge production function

VARIABLES	(1) product	(2) process
Predicted R&D	0.345**	0.403**
International competition	-0.116	-0.500
Formal protection	0.106	-0.231
Size: 50–99	-0.136	0.023
Size: 100–249	0.004	0.191**
Size: >250	-0.062	0.264***
Average wage: 2nd quartile	-0.577	-0.329
Average wage: 3rd quartile	-0.457	-0.347
Average wage: 4th quartile	-0.658	-0.521
Industry dummies	Yes	Yes
Demand pull variables	Yes	Yes
Information source variables	Yes	Yes
Ln likelihood	-2,279	-2,279
Rho	0.347	0.347
Observations	3,619	3,619

Bootstrapped standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Output production function: labour productivity

	(1)
VARIABLES	Labour productivity
pred. process	0.032
pred. product	0.091
Capital intensity	0.290***
Size: 50–99	0.013
Size: 100–249	0.083**
Size: >250	0.146***
Industry dummies	Yes
R-squared	0.359
Observations	3,549

Bootstrapped standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Output production function: labour productivity

	(1)	(2)
VARIABLES	Labour productivity	
pred. process	0.032	
pred. product	0.091	0.120***
Capital intensity	0.290***	0.290***
Size: 50–99	0.013	0.018
Size: 100–249	0.083**	0.089**
Size: >250	0.146***	0.158***
Industry dummies	Yes	Yes
R-squared	0.359	0.358
Observations	3,549	3,549

Bootstrapped standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Output production function: labour productivity

	(1)	(2)	(3)	(4)
VARIABLES	Labour productivity			
pred. process	0.032			
pred. product	0.091	0.120***		
pred. product or process			0.353***	
pred. product and process				0.352***
Capital intensity	0.290***	0.290***	0.291***	0.296***
Size: 50–99	0.013	0.018	0.009	0.012
Size: 100–249	0.083**	0.089**	0.088**	0.106***
Size: >250	0.146***	0.158***	0.150***	0.178***
Industry dummies	Yes	Yes	Yes	Yes
R-squared	0.359	0.358	0.356	0.351
Observations	3,549	3,549	3,549	3,549

Bootstrapped standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Output production function: TFP

	(5)	(6)	(7)	(8)
VARIABLES	Total factor productivity			
pred. process	0.034			
pred. product	0.070	0.100***		
pred. product or process			0.298***	
pred. product and process				0.284***
Size: 50–99	0.107***	0.112***	0.105***	0.108***
Size: 100–249	0.309***	0.316***	0.315***	0.333***
Size: >250	0.633***	0.646***	0.640***	0.669***
Industry dummies	Yes	Yes	Yes	Yes
R-squared	0.224	0.224	0.221	0.216
Observations	3,492	3,492	3,492	3,492

Bootstrapped standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Domestic and foreign firms

	2003		2006	
	Domestic	Foreign	Domestic	Foreign
Observation	1671	714	701	457
Share conducting R&D %	7	16	12	18
R&D intensity, log	-0.34	0.09	-1.14	0.01
Product innovators %	19	34	23	37
Process innovators %	18	30	24	35
Innovators, share %	26	41	35	48
Labour productivity. Log	1.04	1.69	1.16	1.79
TFP. log	0.54	1.1	0.68	1.63

Foreign vs. domestic firms (1)

	R&D	R&D intensity	product	process
Foreign	-0.000	-0.004	-0.026	-0.072
Predicted R&D			0.363 ***	0.412 **
Foreign*Predicted R&D			-0.064	-0.014
Size: 50–99	0.050 ***	0.410 ***	-0.144	0.020
Size: 100–249	0.086 ***	0.705 ***	-0.001	0.187 **
Size: >250	0.129 ***	0.940 ***	-0.068	0.256 ***
Observations	3,619	3,619	3,619	3,619
Ln likelihood	-1429	-1429	-2278.1	-2278.1

Foreign vs. domestic firms (2)

	Labour productivity		TFP	
Foreign	0.419 ***	0.460 ***	0.276 ***	0.350 ***
Predicted product	0.116 ***		0.105 ***	
Foreign*predicted product	-0.035		-0.055 **	
Pred. process and product		0.318 ***		0.284 ***
Foreign*Pred. process and product		-0.012		-0.107
Size: 50–99	-0.011	-0.018	0.086 **	0.082 **
Size: 100–249	0.027	0.042	0.263 ***	0.277 ***
Size: >250	0.044	0.058	0.545 ***	0.561 ***
Observations	3,549	3,549	3,492	3,492
R-squared	0.400	0.395	0.258	0.252

Innovation and export performance

	Exporter	
pred. product or process	0.859 ***	
pred. product and process		1.043 ***
Size: 50–99	0.267 ***	0.271 ***
Size: 100–249	0.487 ***	0.518 ***
Size: >250	0.585 ***	0.640 ***
Industry dummies	Yes	Yes
Pseudo R-squared	0.211	0.207
Ln likelihood	-1,775.8	-1,785.5
Observations	3,614	3,614

Innovation and export performance

	Exporter		Export share	
pred. product or process	0.859 ***		0.081 ***	
pred. product and process		1.043 ***		0.075 ***
Size: 50–99	0.267 ***	0.271 ***	0.084 ***	0.086 ***
Size: 100–249	0.487 ***	0.518 ***	0.179 ***	0.184 ***
Size: >250	0.585 ***	0.640 ***	0.239 ***	0.247 ***
Industry dummies	Yes	Yes	Yes	Yes
Pseudo R-squared	0.211	0.207	-	-
Ln likelihood	-1,775	-1,785	-1,997	-2,000
Observations	3,614	3,614	3,619	3,619

Decomposition of export (1)

Variables	Markets		Products	
Estimator	Poisson			
pred. product or process	0.565 ***		0.440 ***	
pred. product and process		0.529 ***		0.441 ***
Size: 50–99	0.320 ***	0.330 ***	0.252 **	0.257 **
Size: 100–249	0.429 ***	0.465 ***	0.257 ***	0.280 ***
Size: >250	0.732 ***	0.785 ***	0.375 ***	0.411 ***
ln likelihood	-8,042	-8,074	-8,170	-8,185
Observations	3,619	3,619	3,619	3,619

Decomposition of export (2)

	Extensive		Intensive	
	Tobit			
pred. product or process	4.344 ***		848 ***	
pred. product and process		4.434 ***		962 ***
Size: 50–99	1.207 **	1.250 **	267 *	271 *
Size: 100–249	0.689	0.904 *	-53	-21
Size: >250	2.129 ***	2.460 ***	624 ***	669 ***
ln likelihood	-6,279	-6,286	-13,049	-13,050
Observations	3,619	3,619	3,619	3,619

Conclusions

- In Hungary we detect a relatively low return on R&D
- Innovative firms are 30 % more productive in Hungary
- Weaker relationship between domestic R&D and innovation for foreign firms
- Innovation is strongly related to different margins of exporting