

**Competition, R&D and innovation:  
testing the *inverted-U* in a simultaneous  
system**

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- **Theoretical background**
- **Data**
- **Structural model**
- **Empirical findings**
  - **Dynamic adjustment**
- **Policy conclusions**
- *Annex*

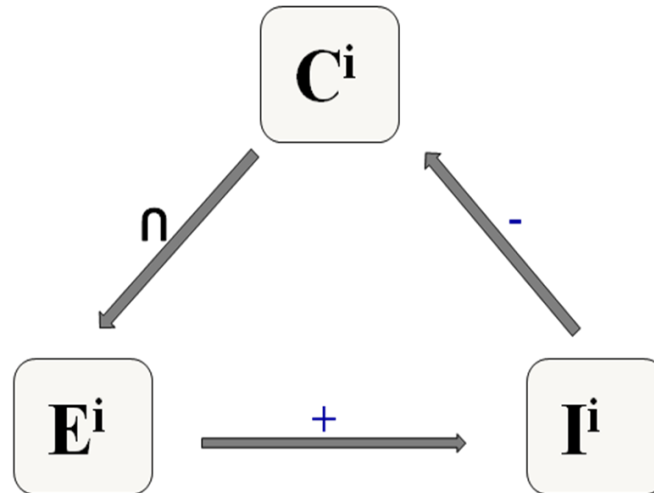
- **Schumpeter (1911, 1942)**
  - Incompatibility of endogen. innovation and perfect competition
  - Negative impact (at high levels of competition)
- **Arrow (1962)**
  - Positive impact (at low levels of competition)
- **Kamien-Schwarz (1976)**
  - Innovation race with effort depending on number of rivals, demand growth, post-innovation rents, etc.
- Vast **game theoretic** literature: ‘anything goes’
- **Aghion et al (2005)**
  - Pre- vs post innovation rents, composition effect
  - Triggered much new empirical analyses

- **Swiss Innovation Survey by KOF-ETH**
- **Unbalanced firm panel observed across five periods**
- **Stratified random sample (firms > 5 employees) in the manufacturing, construction, and service sectors**

Year	Number of firms	Response rate
1994/1996	1748	32.5%
1997/1999:	2172	33.8%
2000/2002:	2583	39.6%
2003/2005:	2555	38.7%
2006/2008 :	2141	36.1%

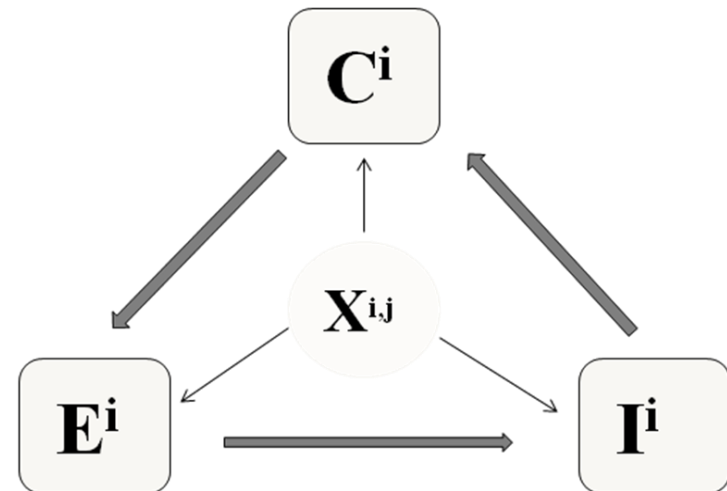
- **Econometric estimations are based on 8,656 observations!**

- **C**ompetition – **E**ffort (R&D) – **I**nnovation

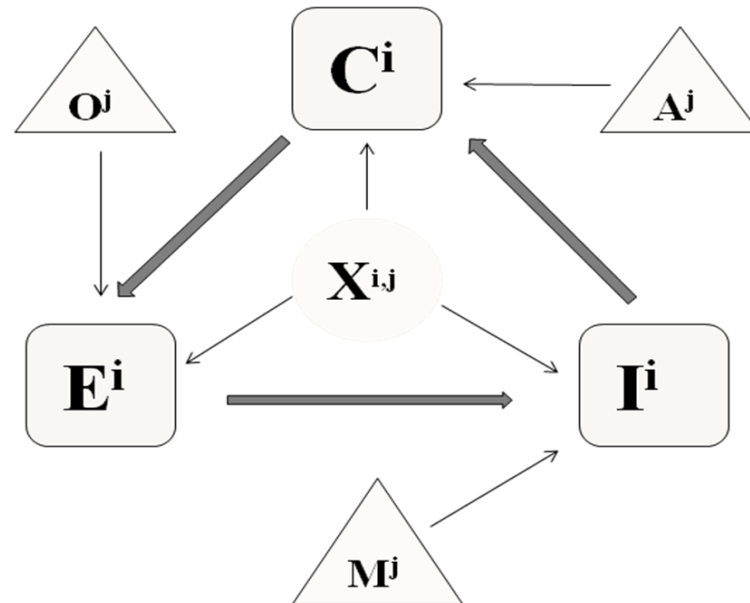


- Innovation **opportunity** function ( $C \rightarrow E$ )
- Innovation **production** function ( $E \rightarrow I$ )
- Innovation **impact** function ( $I \rightarrow C$ )

- Technological potential
- Demand growth
- Capital intensity
- Human capital
- Firm size
- Firm age
- Exports
- Foreign ownership
- Industry & time effects



- Identify exogenous **instrumental variables**



- **Technological regimes at the EU sector level**
  - **Opportunity** conditions
  - **Cumulativeness** of knowledge
  - **Appropriability** conditions

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- **Simultaneous system** of three equations

$$(1) \quad E_i = \alpha_1 + \beta_1 C_i + \theta_1 C_i^2 + \gamma_1 X_i + \delta_1 O_j + v_{1i}$$

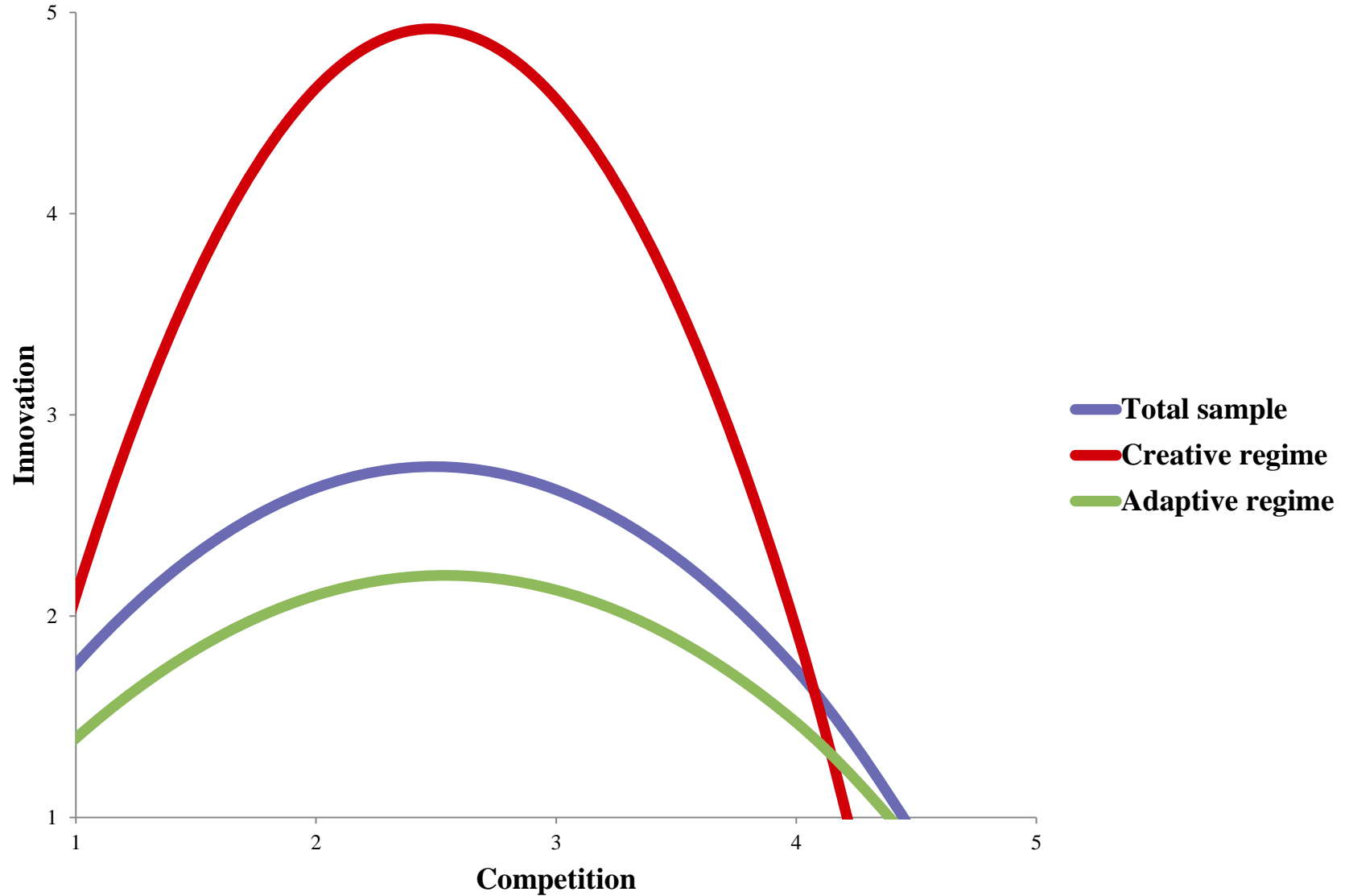
$$(2) \quad I_i = \alpha_2 + \beta_2 E_i + \gamma_2 X_i + \delta_2 M_j + v_{2i}$$

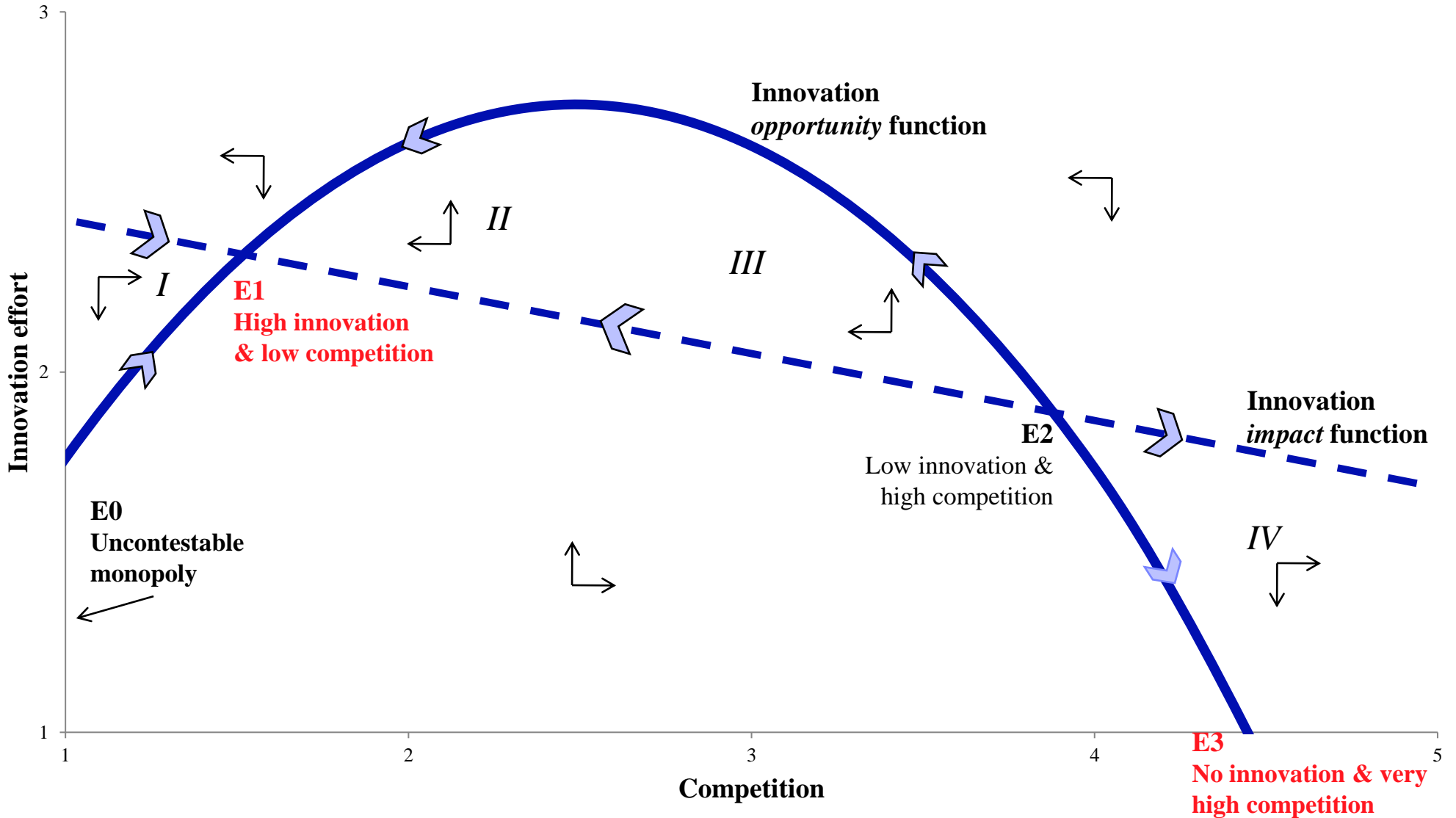
$$(3) \quad C_i = \alpha_3 + \beta_3 I_i + \gamma_3 X_i + \delta_3 A_j + v_{3i}$$

- **3SLS method**; instruments pass overidentification, underidentification and weak instrument tests
- **Robustness checks**: traditional 2SLS; ordered probit; no sector dummies; endogenized squared term; more time varying instruments; panel with lag structure
  - **Robust relationships among endogenous variables!**

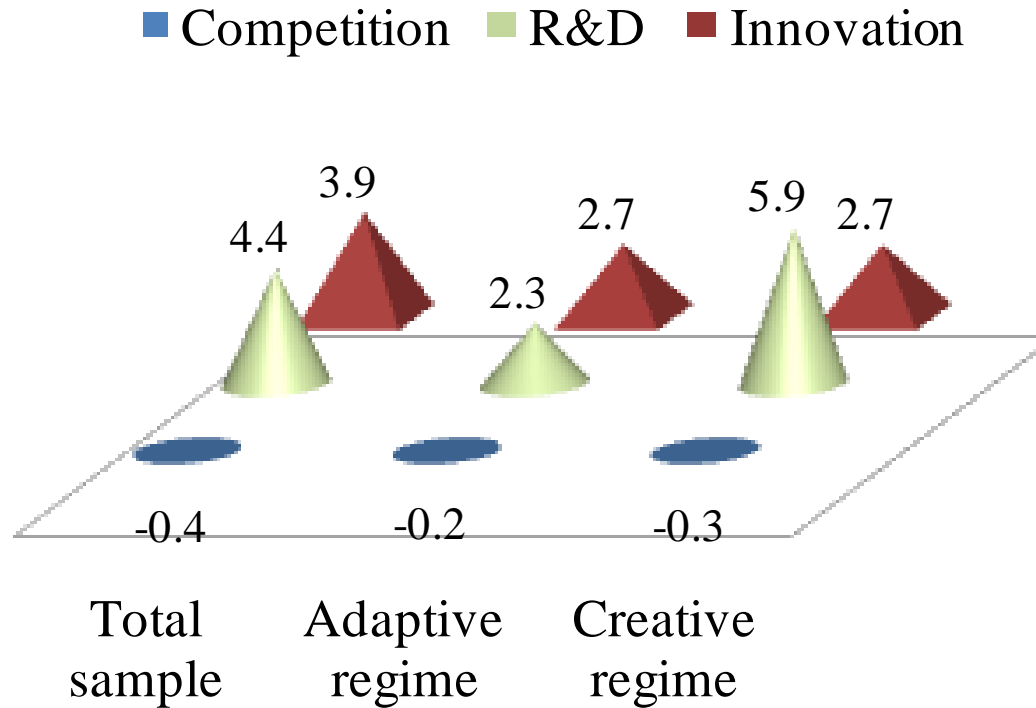


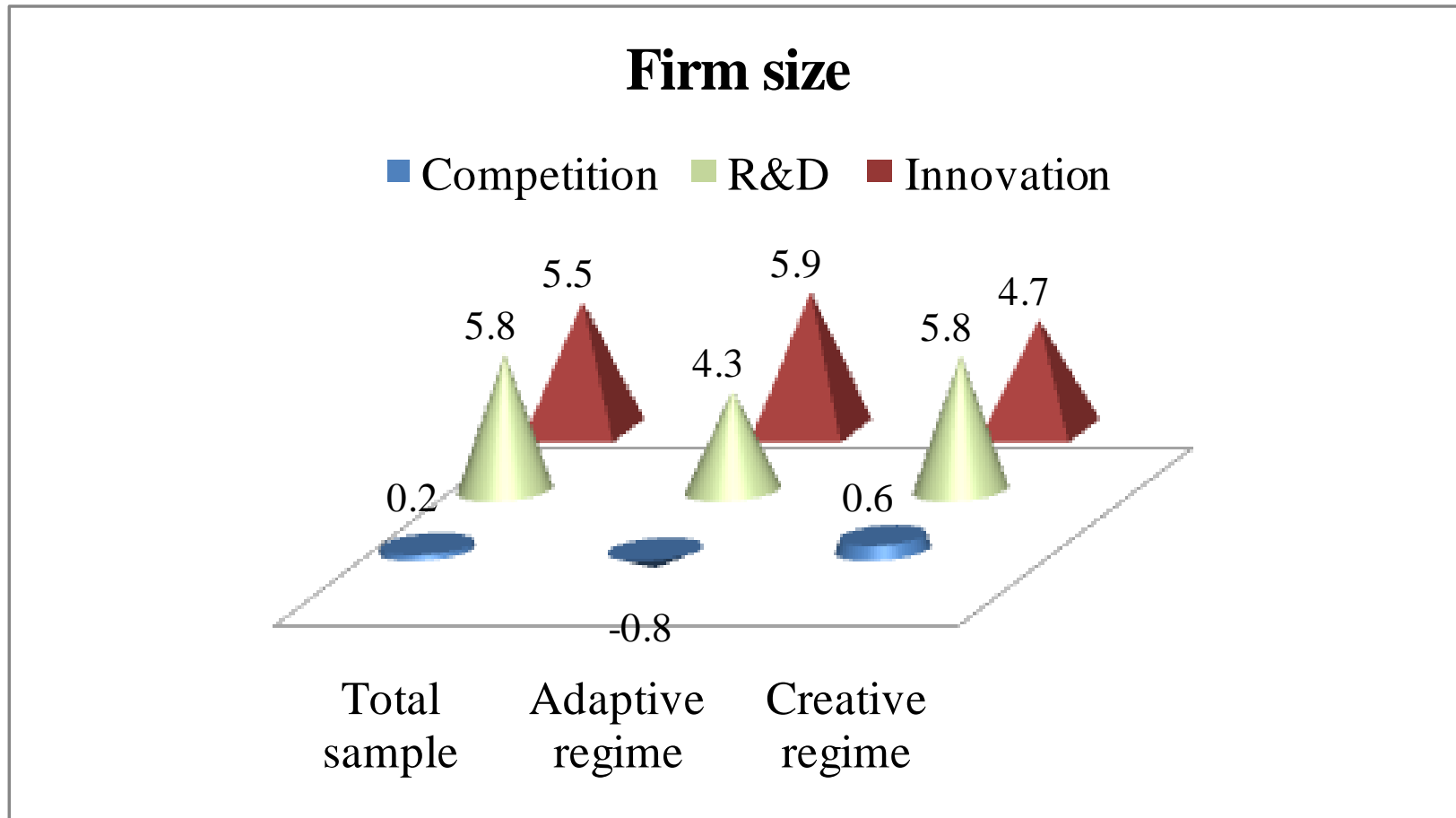
Independent variables	Total sample		Creative firms		Adaptive firms	
	Coef.		Coef.		Coef.	
$C_i$	<b>2.2038</b>	***	<b>6.3907</b>	***	<b>1.7355</b>	***
	(0.5011)		(1.1993)		(0.4195)	
$C_i^{\text{squared}}$	<b>-0.4426</b>	***	<b>-1.2892</b>	***	<b>-0.3419</b>	***
	(0.0969)		(0.2344)		(0.0802)	
$tp_i$	<b>0.0906</b>	***	0.1043	***	0.0593	***
	(0.0092)		(0.0185)		(0.0098)	
$hc_i$	<b>0.0254</b>		0.0910	*	-0.0263	
	(0.0265)		(0.0510)		(0.0281)	
$g_i$	<b>0.0337</b>	***	0.0428	**	0.0418	***
	(0.0106)		(0.0197)		(0.0121)	
$g_i^e$	<b>0.0781</b>	***	0.1336	***	0.0323	**
	(0.0120)		(0.0228)		(0.1293)	
$s_i^{\text{small}}$	<b>-0.1527</b>	***	-0.0784		-0.0871	**
	(0.0359)		(0.0738)		(0.0400)	
$s_i^{\text{med}}$	<b>-0.1341</b>	***	-0.2259	***	-0.0267	
	(0.0364)		(0.0657)		(0.0422)	
$s_i^{\text{very large}}$	<b>0.1433</b>	***	0.2301	***	0.1081	**
	(0.0408)		(0.0752)		(0.0468)	
$O_j$	<b>0.1958</b>	***	0.1744	***	0.0913	*
	(0.0407)		(0.0238)		(0.0470)	
No Obs.	<b>8,656</b>		4,513		4,143	

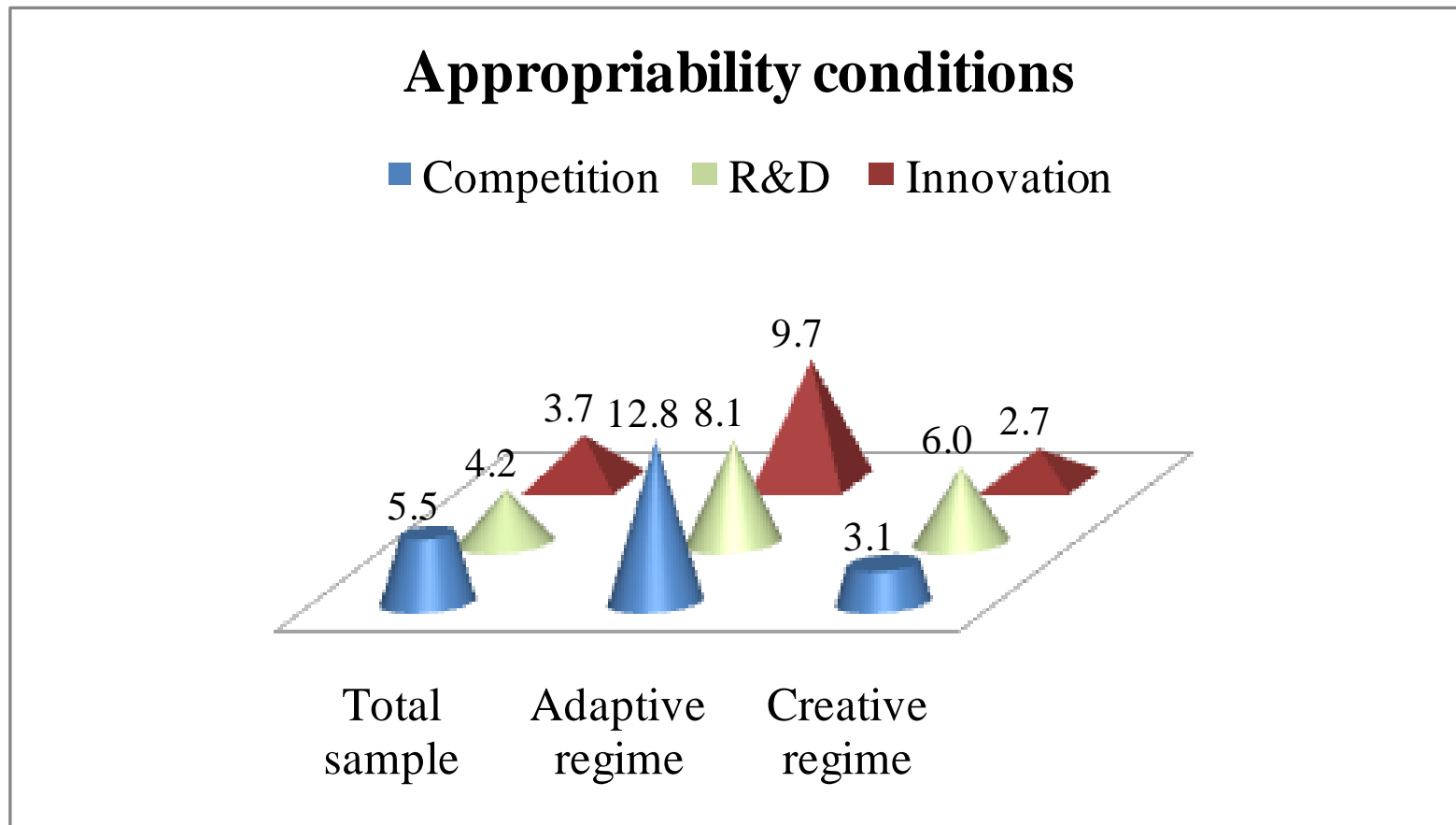




## Expected demand growth, 3 years







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- **Impact of competition on innovation follows an inverted-U shape**
    - Highest innovation at intermediate levels of competition, but little innovation if monopoly or very high competition
  - **Creative** entrepreneurs are more sensitive to changes in competition than **adaptive** firms
  - **Possible solutions to the model**
    - [Uncontested monopoly with no or low innovation]
    - Low competition & high innovation
    - High competition & low innovation (unstable)
    - Very high competition & no innovation

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- Individual outcomes depend on *regime-*, *industry-*, and *firm* specific characteristics (heterogenous intercepts)
  - For the **average firm**, we observe that
    - Demand growth, technology potential, firm size and exports increase innovation effort and outcome, while leaving competition largely unaffected
    - Foreign ownership tends to decrease innovation, mainly effort and to a lesser degree outcome
  - Technological regimes (sectoral instruments)
    - Higher opportunity has a negative, and higher appropriability a positive impact on competition



## Competition policy

- **Further competition is detrimental to innovation at already high levels of competition → antitrust authorities typically not involved!**
- **Further competition is conducive to innovation at low levels of competition → antitrust measures can raise competition and innovation!**

## Industrial policy

- **‘No-innovation trap’ (negative spiral of increasing competition and less to no innovation) → innovation policies for low innovation firms ?**

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- **Description of the variables**
    - **Endogenous variables**
    - **Control variables**
    - **Instrumental variables**
  - **Additional estimates**
    - **innovation *production* function**
    - **innovation *impact* function**
  - **Simulation of changes in exogenous variables**

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<b>C<sub>i</sub></b>	<b>Competition</b>	Number of principal competitors in the main product market worldwide; subjective firm assessment according to the following ordinal scale: 1 ... Number of principal competitors $\leq 5$ 2 ... Number of principal competitors $> 5$ & $\leq 15$ 3 ... Number of principal competitors $> 15$ & $\leq 50$ 4 ... Number of principal competitors $> 50$
<b>O<sub>i</sub></b>	<b>Opportunity type</b>	1 ... No innovation activity 2 ... External acquisition of new technology 3 ... Own R&D, but R&D expenditures less than 5% of total sales 4 ... Own R&D, but R&D expenditures $> 5\%$ of total sales
<b>E<sub>i</sub></b>	<b>Entrepreneurship type</b>	1... <b>Adaptive 1</b> : Pursuing opportunities other than from techn. innov. 2... <b>Adaptive 2</b> : introducing new products and/or processes new to their firm but not new to the market (Technology adopters) 3... <b>Creative 1</b> : Product and/or process innovator (new to the firm) developing the innovation predominantly on their own 4... <b>Creative 2</b> : introducing products new to the market

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$tp_i$	<b>Technological potential</b>	Firm's assessment of the technological potential (worldwide available knowledge to further the innovation activities of the firm) on a five point Likert-scale (1 low ...5 great)
$k_i$	<b>Capital intensity</b>	Natural logarithm of revenues (per employee) due to fixed capital (= turnover – intermediary products – personnel costs)
$hc_i$	<b>Human capital</b>	Natural logarithm of average labor cost per employee
$g_i$	<b>Demand growth</b>	Firm's assessment of the demand development during the past 3 years on a five point Likert-scale (1 strong decline ... 5 remarkable increase)
$g_i^e$	<b>Expected demand growth</b>	Firm's assessment of the expected demand development in the coming 3 years on a five point Likert-scale (1 strong decline ... 5 remarkable increase)
$s_i$	<b>Firm size</b>	4 size classes (dummy variables): small (number of employees < 50); medium (number of employees $\geq 50$ & < 150); large (number of employees $\geq 150$ & < 250); very large (number of employees $\geq 250$ ). Large firms are the reference category in the estimations
$f_i$	<b>Foreign ownership</b>	Dummy variable indicating whether a firm is owned by a foreign company
$e_i$	<b>Exports</b>	Dummy variables indicating whether a firm has export activities
$a_i$	<b>Firm age</b>	Firm age in years

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Three **taxonomies of technological regimes** based on a sample of 78 thousand firms from **22 European countries** and clustering sectors by relative differences in the distribution of heterogenous firm types (see *Peneder, 2010*). The sectors are classified according to a characteristically high share of firms in Europe (other than Switzerland) with ...

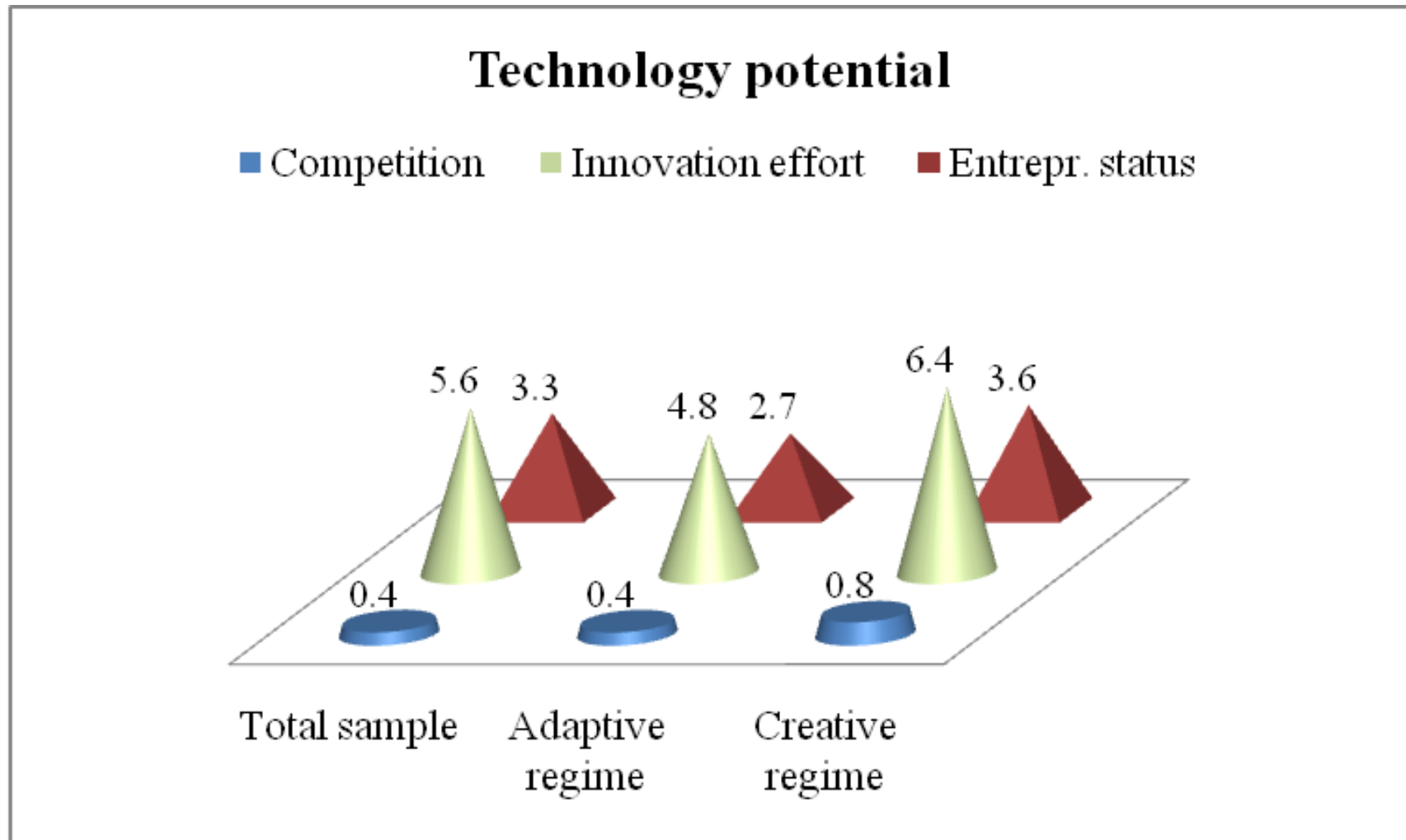
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$O_j$	<b>Opportunity conditions</b>	<ol style="list-style-type: none"><li>1... neither intramural nor external R&amp;D activities</li><li>2... acquisition of external R&amp;D, machinery, rights, etc.</li><li>3... own R&amp;D, but less or equal 5% of total sales</li><li>4 ...own R&amp;D, more than 5% of total sales</li></ol>
$A_j$	<b>Appropriability conditions</b>	<ol style="list-style-type: none"><li>1 ... no appropriation measures</li><li>2 ... appropriation only by secrecy, lead-time, or complexity of design</li><li>3 ... appropriation by design patterns, trademarks, or copyright (with or without strategic methods)</li><li>4 ... appropriation by patents (alone or with either strategic or other formal methods)</li><li>5 ... appropriation by patents together with other formal and strategic methods</li></ol>
$M_j$	<b>Cumulativeness of knowledge</b>	<ol style="list-style-type: none"><li>1 ... reporting neither internal nor external knowledge sources of high importance</li><li>2 ... creative firms with internal sources less important than external sources; and/or adaptive firms with internal sources more or equally important</li><li>3 ... creative firms with internal sources more or equally important than external sources; and/or adaptive firms with external sources more important</li></ol>

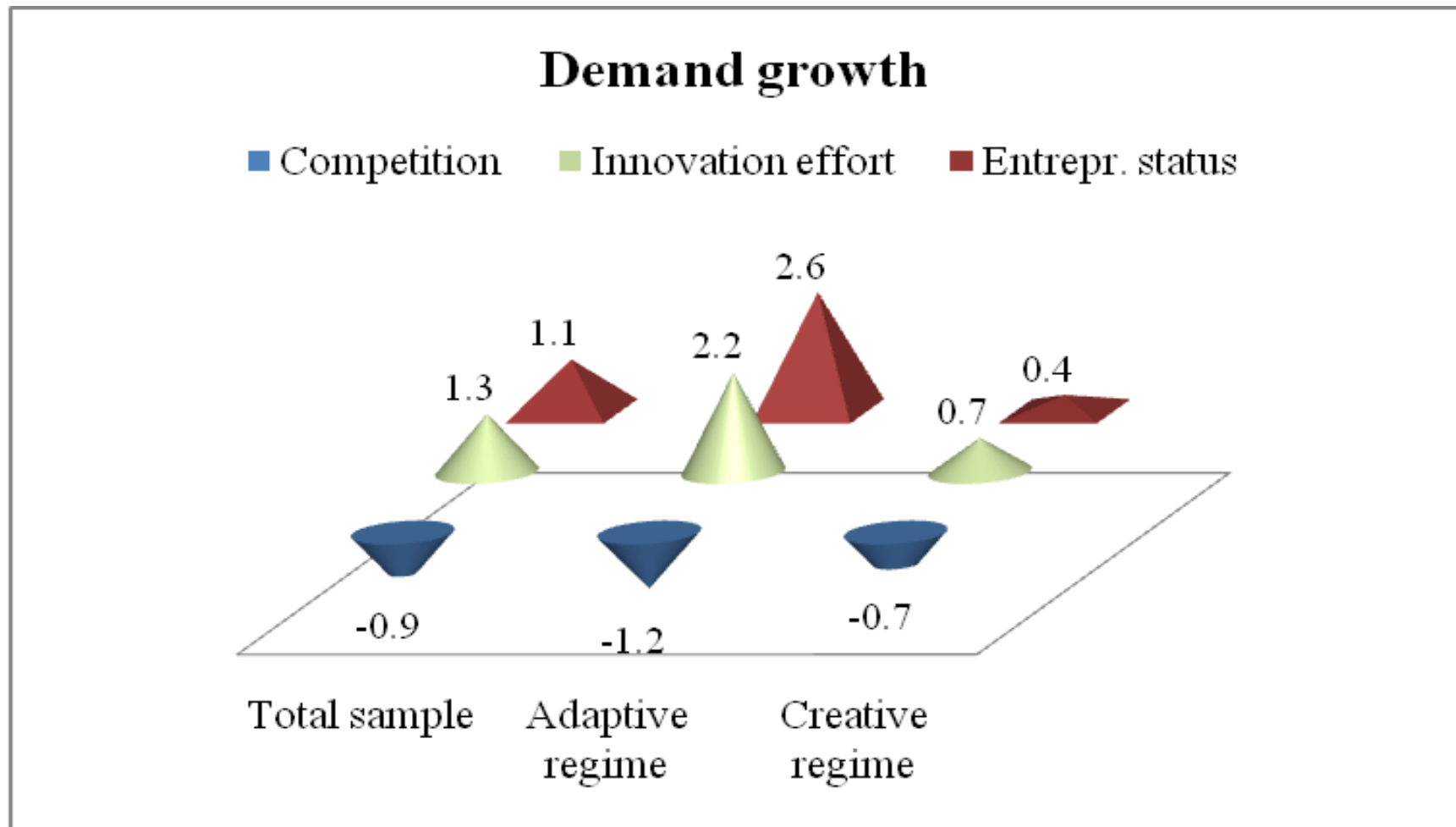
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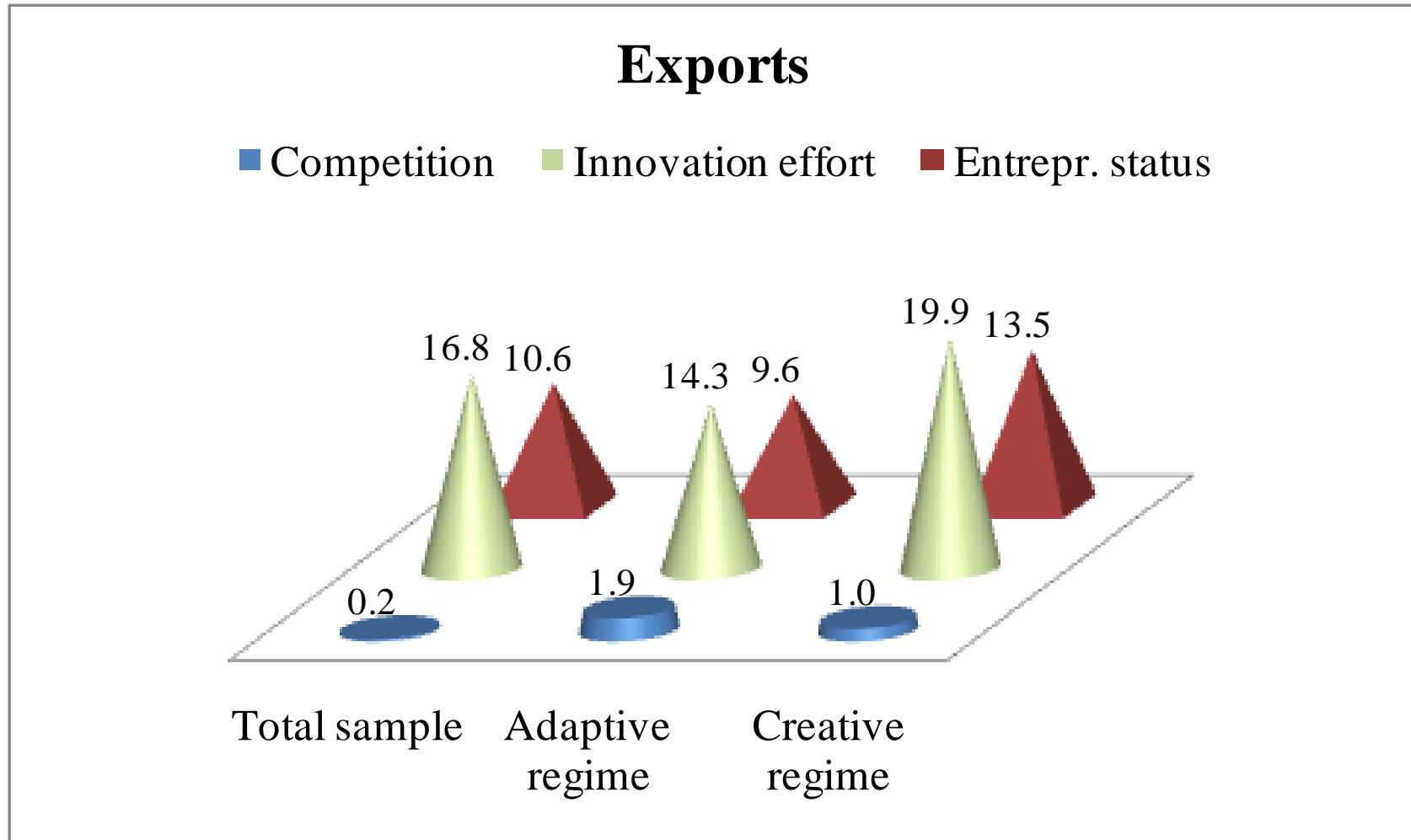
Variables	Total sample		Creative regime		Adaptive regime	
	Coef.		Coef.		Coef.	
$O_i$	<b>1.1137</b>	***	<b>0.5230</b>	***	<b>1.7045</b>	***
	(0.0788)		(0.0463)		(0.1816)	
$tp_i$	<b>-0.0369</b>	***	0.0146		-0.0584	***
	(0.0120)		(0.0137)		(0.0177)	
$hc_i$	<b>-0.0367</b>		-0.0215		-0.0214	
	(0.0259)		(0.0331)		(0.0387)	
$s_i^{small}$	<b>0.0567</b>		-0.0422		0.0320	
	(0.0383)		(0.0459)		(0.0579)	
$s_i^{med}$	<b>0.1248</b>	***	0.0420		0.0678	
	(0.0370)		(0.0454)		(0.0574)	
$s_i^{very\ large}$	<b>0.0685</b>	*	0.1014	**	0.0719	
	(0.0405)		(0.0489)		(0.0655)	
$M_j$	<b>-0.0415</b>	*	0.0285	**	-0.2615	***
	(0.0242)		(0.0127)		(0.0675)	
No Obs.	<b>8,656</b>		4,513		4,143	

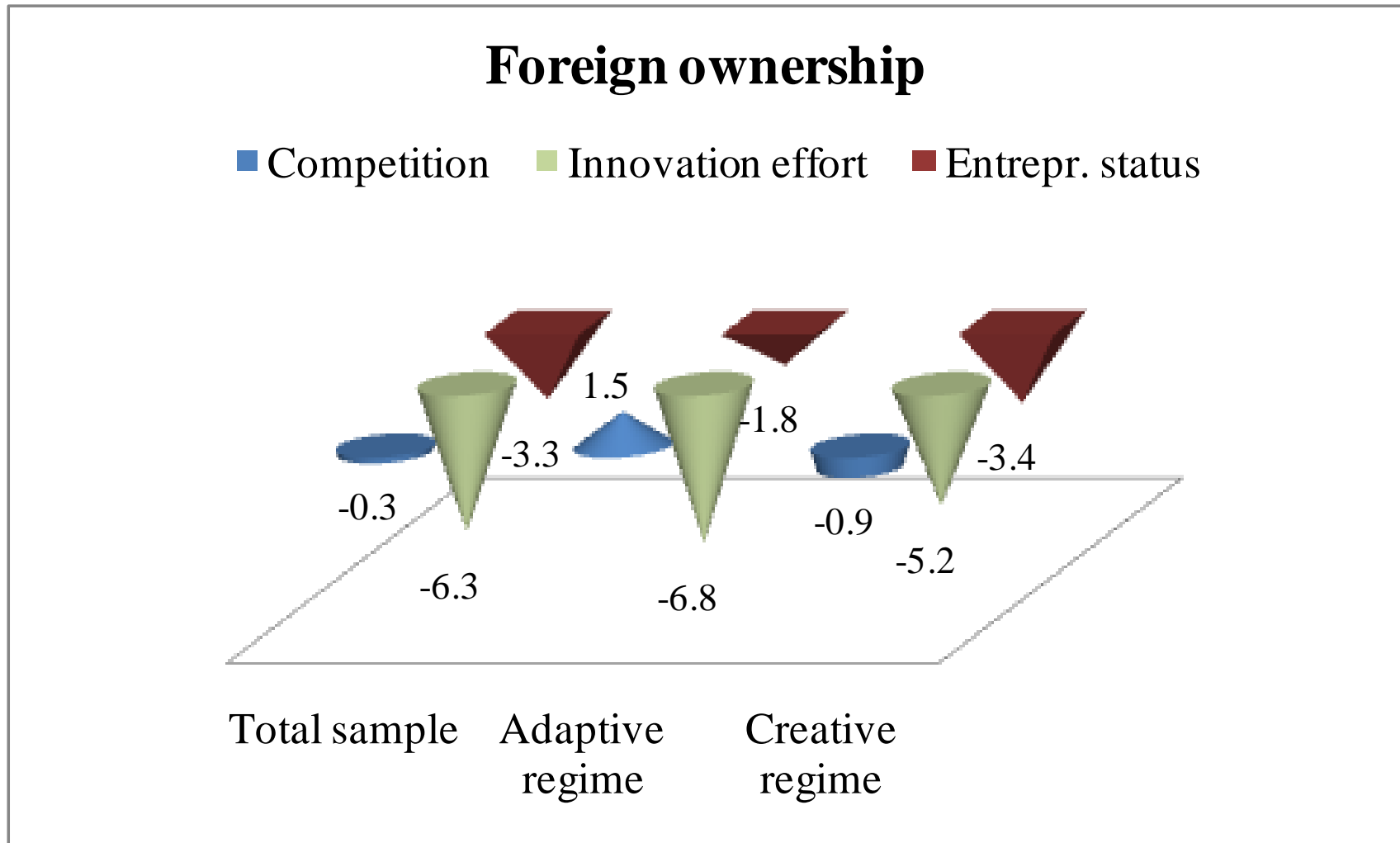
Independent variables	Total sample		Creative regime		Adaptive regime	
	Coef.		Coef.		Coef.	
$E_i$	<b>-11.1253</b>	***	<b>-9.4710</b>	***	<b>-11.4623</b>	***
	(1.0697)		(0.9133)		(1.7354)	
$tp_i$	<b>0.7899</b>	***	0.8068	***	0.5803	***
	(0.1237)		(0.1346)		(0.1493)	
$hc_i$	<b>-0.0772</b>		0.0545		-0.8527	**
	(0.2756)		(0.3036)		(0.3756)	
$g_i$	<b>0.2560</b>	***	0.0692		0.5402	***
	(0.0827)		(0.0762)		(0.1427)	
$g_i^e$	<b>0.9023</b>	***	0.5940	***	0.5817	***
	(0.1255)		(0.1178)		(0.1683)	
$s_i^{\text{small}}$	<b>-1.7170</b>	***	-1.7254		-1.4122	**
	(0.4087)		(0.4380)		(0.5616)	
$s_i^{\text{med}}$	<b>-0.2461</b>		-0.8397	**	0.5045	
	(0.3804)		(0.4123)		(0.5397)	
$s_i^{\text{very large}}$	<b>2.1895</b>	***	1.4958	***	2.3099	***
	(0.4743)		(0.4695)		(0.6990)	
$A_j$	<b>0.9510</b>	***	0.6231	***	2.4258	***
	(0.1788)		(0.0805)		(0.4047)	
No Obs.	<b>8,656</b>		4,513		4,143	

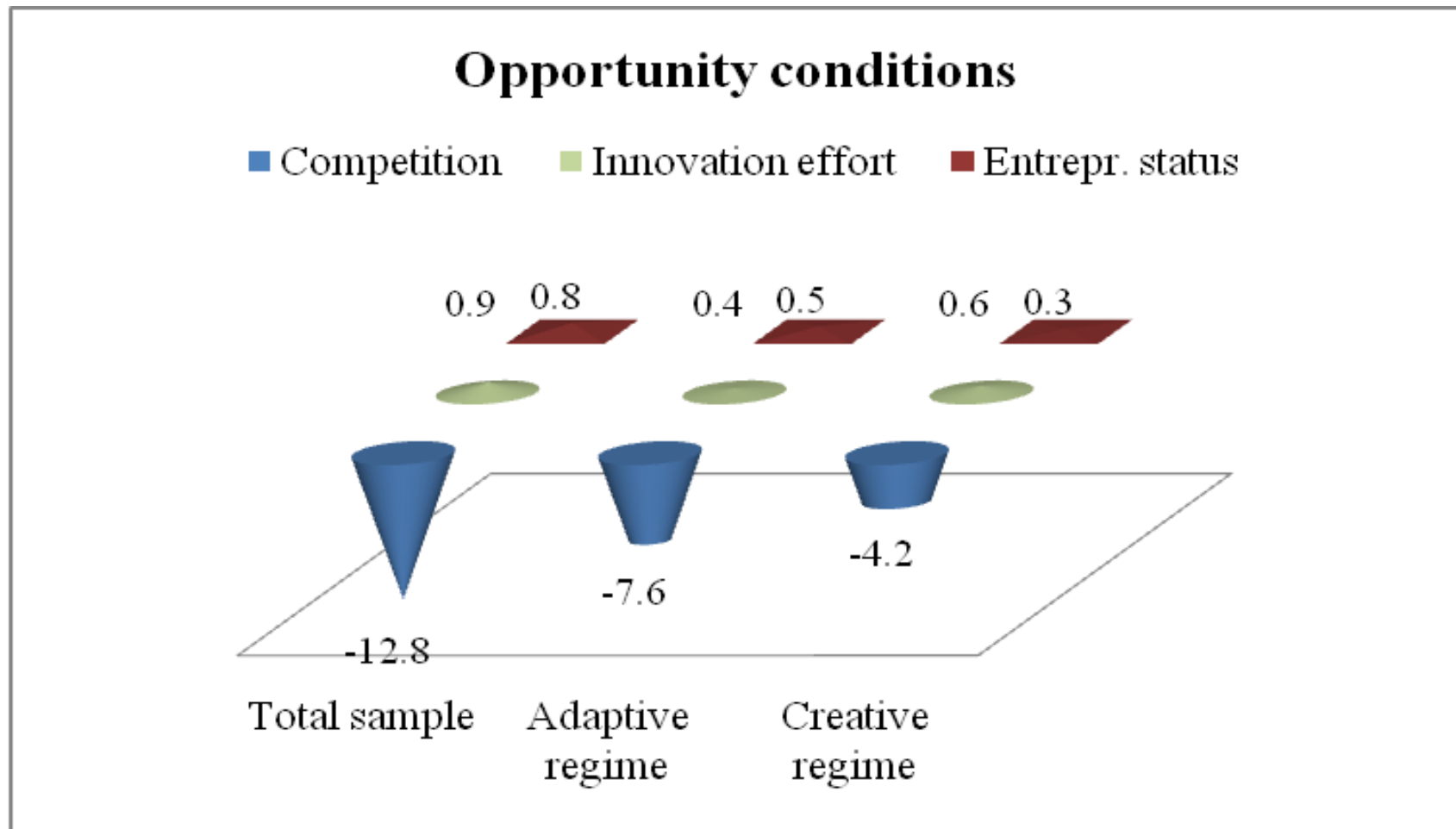












### Cumulativeness of knowledge

■ Competition   ■ Innovation effort   ■ Entrepr. status

