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Competitiveness and innovation in Europe.
The dynamics of export success, R&D and new
products in EU industries

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Competitiveness and innovation in Europe. The dynamics of export success, R&D and new products in EU industries

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Outline

- Motivation
- Related literature
- Model and theoretical framework
- Data and descriptive evidence
- Econometric strategy
- Results:
 - 1 The 'virtuous circle' between R&D, new products and export market shares
 - 2 The impact of country groups, Up and Downswings of business cycles, manufacturing/services and technology clusters
- Conclusions and final remarks

Motivation

- **Disentangling the complex set of relationships between innovation and competitiveness**
- Variety of Innovation: Technology (new products) vs Cost Competitiveness (new processes) (*Schumpeter, 1942*)
- Need to account for heterogeneity, lags, path-dependency and 'virtuous circles' (*Pianta, 2014; Arthur, 2014*)
- Highlighting the role of business cycles as drivers of economic development (*Marx 1867, Schumpeter 1942; Arrighi, 1994; Freeman and Louca 2001*)

Motivation

- **Using models and empirical strategies to bridge different 'out of equilibrium' views:**
- Combining the evolutionary 'supply side' view (irreversibility, cumulative nature and heterogeneity of innovation) with a 'demand push' approach (From demand to new products and structural change, *Schmookler, 1966; Scherer, 1982; Pasinetti 1981 and 1986*)
- A structural approach (Crepon et al., 1998 and Guarascio et al., 2015) to distinguish between input and output of innovation (*Pianta, 2001*)
- Industry-level analysis and Input-Output tables (WIOD) to account for, demand, structural inter dependencies and international fragmentation of production
- Testing empirically if and how well established stylized facts are reshaped by business cycle dynamics (*Lucchese & Pianta, 2012*)

Related Literature

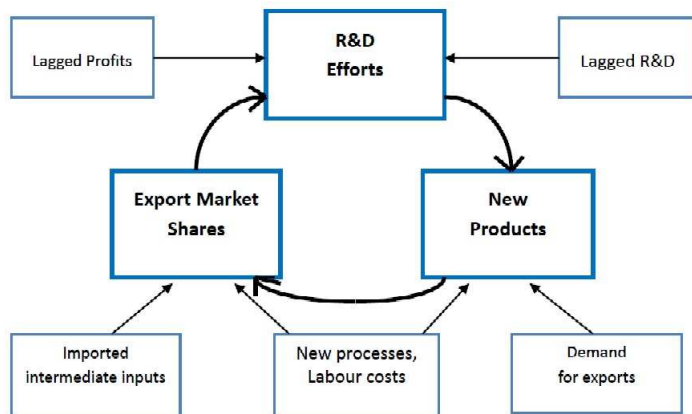
- Evolutionary view of innovation (*Nelson & Winter, 1982; Dosi, 1982 and 1988; Malerba 2004; Metcalfe, 2010*)
- Structural change and the role of demand (*Kaldor, 1981; Pasinetti, 1986*)
- The link between innovation and international competitiveness (*Amendola et al., 1993; Carlin et al., 2001; Laursen & Meliciani, 2010 and Dosi et al., 1990 and 2014*)
- The link between international fragmentation of production and export success (*Hummels et al., 2001; Falzoni & Tajoli, 2011*)

Model and conceptual framework

- Analyzing in an integrated view (*extension of Crepon et al., 1998; Bogliacino & Pianta, 2013 and Guarascio et al., 2015*) three key relationships between innovation and international competitiveness:
 - ① **R&D Efforts \Rightarrow Innovative Performance**
 - ② **Innovative Performance \Rightarrow Export Market Shares**
 - ③ **Export Market Shares \Rightarrow R&D Efforts**
- Inquiring the existence of *feedback* and *circles* between R&D intensity, share of product innovators and export market share in European industries
- Testing our complex system of relationships accounting for: country-level heterogeneity (North vs South); Up and Downswing of business cycle; Manufacturing vs Services; Technology Clusters (Using the *Revised Pavitt Taxonomy*, Bogliacino & Pianta, 2015)

The R&D-Innovation-Export 'virtuous circle'

Fig.1: The 'Virtuous Circle'



Model and conceptual framework

- The decision to carry out R&D efforts. A 'Schumpeterian' specification of the 'Knowledge Production Function' as modeled by Crepon et al. (1998):

$$\log(Z_{ijt}) = \log(Z_{ijt-1}) + \log(Si_{ijt}) + \log(Fr_{ijt}) + \log(\pi_{ijt-1}) + \log(Sh_{ijt-1}) + \nu_{ij} + \epsilon_{ijt}$$

- Differentiating to get rid of the fixed effects:

$$\Delta \log(Z) = \Delta \log(Z_{t-1}) + \Delta \log(Si) + \Delta \log(Fr) + \Delta \log(\pi_{t-1}) + \Delta \log(Sh_{t-1}) + \epsilon$$

- Then, the empirical specification:

$$R\&D = \beta_1 * L.R\&D + \beta_2 * SIZE + \beta_3 * FR + \beta_3 * L.PROF + \beta_4 * L.EXSH + \epsilon$$

- 1 R&D as a path dependent process paradigm related and imitation matters (evolutionary approaches) **L.R&D and Distance from the frontier** \Rightarrow **R&D**
- 2 'Schumpeterian' effects: **Firms' size & Lagged profits** \Rightarrow **R&D**
- 3 International performances: **Lagged Exp. Shares** \Rightarrow **R&D**

Model and conceptual framework

- **R&D equation: the 'distance from the technological frontier' variable**
- The distance from the technological frontier (FR), is interpreted here as the greater need to carry out R&D when the opportunities (distance) for imitating technology leaders are lower (Dosi, 1988)
- Our 'catching up' indicator is calculated as the percentage distance of industry labour productivity (LP) from the highest value for the same industry in the sample
- The formal definition is the following:

$$FR_{ijt} = \frac{|LP_{i,j,t} - LP_{i,jMax,t}|}{LP_{i,j,t}}$$

$$i \in \{NACE\}$$

$$j \in \{GER, SP, FR, IT, NL, UK\}$$

Model and conceptual framework

- Explaining product innovation. 'Technology push' beside 'demand pull' (*Schmookler, 1966; Scherer, 1982*) effects:

$$\log(NP_{ijt}) = \log(Z_{ijt-1}) + \log(Si_{ijt}) + \log(K_{ijt}) + \log(Dem_{ijt}) + \log(Exp_{ijt}) + v_{ij} + e_{ijt}$$

- Differentiating to get rid of the fixed effects:

$$\Delta \log(NP) = \Delta \log(Z_{t-1}) + \Delta \log(Si) + \Delta \log(K) + \Delta \log(DEM) + \Delta \log(EXP) + e$$

- Then, the empirical specification:

$$NEWPR = \beta_1 * L.R\&D + \beta_2 * SIZE + \beta_3 * MACH + \beta_4 * DEM + \beta_5 * EXP + e$$

- 1 Technological competitiveness: **L.R&D \Rightarrow Innovative Performance**
- 2 Cost competitiveness (complementarity vs substitution effects): **Exp. For New Machineries \Rightarrow Innovative Performance**
- 3 Demand matters: **Domestic Demand, Exports \Rightarrow Innovative Performance**

Model and conceptual framework

- The international performance equation. Extending the theoretical specification of Carlin et al. 2001 (Cournot model of competition in open economy) including product, process innovation and offshoring variables:

$$\log(Int_{ijt}) = \log(Np_{ijt-1}) + \log(K_{ijt-1}) + \log(Ulc_{ijt}) + \log(Offsh_{ijt}) + \xi_{ij} + \eta_{ijt}$$

- Differentiating to get rid of the fixed effects:

$$\Delta \log(Int) = \Delta \log(Np_{t-1}) + \Delta \log(K_{t-1}) + \Delta \log(Ulc) + \Delta \log(Offsh) + \Delta \log(Exp) + \eta$$

- Then, the empirical specification:

$$EXPSH = \beta_1 * L.NP + \beta_2 * L.MACH + \beta_3 * ULC + \beta_4 * OFFSH + \eta$$

- 1 Innov. affecting export market share: **Innovative Performance** \Rightarrow **Expsh**
- 2 Cost competitiveness: **New Machinery & Lab.Cost** \Rightarrow **Expsh**
- 3 Production fragmentation: **Intern. Inputs** (imported, distinguished between high and low tech) \Rightarrow **Expsh**

Model and conceptual framework

- **The simultaneous system of three equations:**

$$\begin{cases} R\&D = \beta_1 * L.R\&D + \beta_2 * SIZE + \beta_3 * L.PROF + \beta_4 * EXSH + \epsilon \\ NEWPR = \beta_1 * L.R\&D + \beta_2 * EXMCH + \beta_3 * DEM + \beta_4 * EXP + \epsilon \\ EXSH = \beta_1 * L.NEWPR + \beta_2 * L.EXMCH + \beta_3 * L.COST + \beta_4 * OFFSH + \epsilon \end{cases}$$

- A three equation model where the main *engines* of the circle are:

- 1 **PRODUCT INNOVATION**
- 2 **ECONOMIC PERFORMANCES** (Lagged Profits and Export market shares)
- 3 **R&D EFFORTS**

Data and descriptive evidence

- The Database: Sectoral Innovation Database, University of Urbino (recent efforts for enlargement, *Pianta et al., 2015*):
 - ① 38 sectors both manufacturing and services for the major EU countries
 - ② Data from CIS2, CIS3, CIS4 and CIS6 for innovation variables - Conversion matrix to overcome CIS structural break in industries classification
 - ③ Covering a time span from 1995 to 2011
 - ④ Data from OECD STAN and WIOD-SEA for production variables (Nace two digits, 1995-2011)
 - ⑤ Data for demand variables and export market shares from GLOBAL WIOD-IO tables (1995-2011)

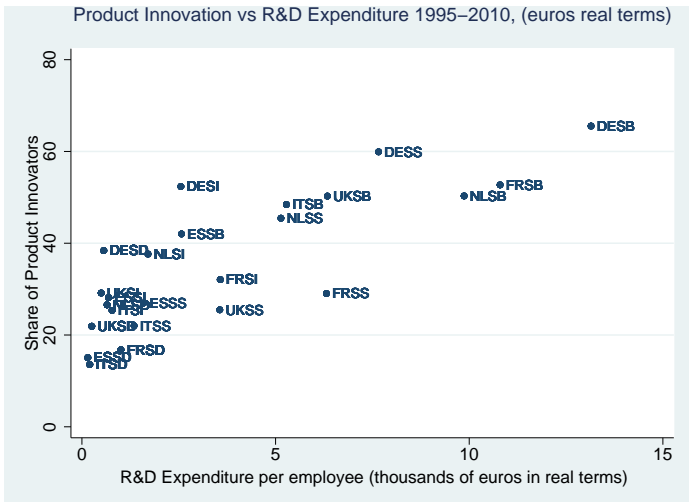
Data and Descriptive Evidence

Tab.1: List of Variables

Variables	Unit	Source
<i>In-house R&D expenditure per employee</i>	<i>Thous. euros/employee</i>	<i>CIS</i>
<i>New Machinery expenditure per employee</i>	<i>Thous. euros/employee</i>	<i>CIS</i>
<i>Share of product innovators</i>	<i>Numb. of firms/Tot. firms</i>	<i>CIS</i>
<i>Share of firms innovating with the aim of opening new markets</i>	<i>Numb. of firms/Tot. firms</i>	<i>CIS</i>
<i>Average firm size</i>	<i>Number of employee per firm</i>	<i>CIS</i>
<i>Compound rate of growth of exports</i>	<i>Annual rate of growth</i>	<i>WIOD I-O Tabs</i>
<i>Compound rate of growth of value added</i>	<i>Annual rate of growth</i>	<i>WIOD I-O Tabs</i>
<i>Compound rate of growth of final demand</i>	<i>Annual rate of growth</i>	<i>WIOD I-O Tabs</i>
<i>Compound rate of growth of interm. demand</i>	<i>Annual rate of growth</i>	<i>WIOD I-O Tabs</i>
<i>Compound rate of growth of imported (high-low tech) intermediate inputs</i>	<i>Annual rate of growth</i>	<i>WIOD I-O Tabs</i>
<i>Compound rate of growth of wages</i>	<i>Annual rate of growth</i>	<i>STAN OECD</i>
<i>Compound rate of growth of gross operating surplus</i>	<i>Annual rate of growth</i>	<i>STAN OECD</i>

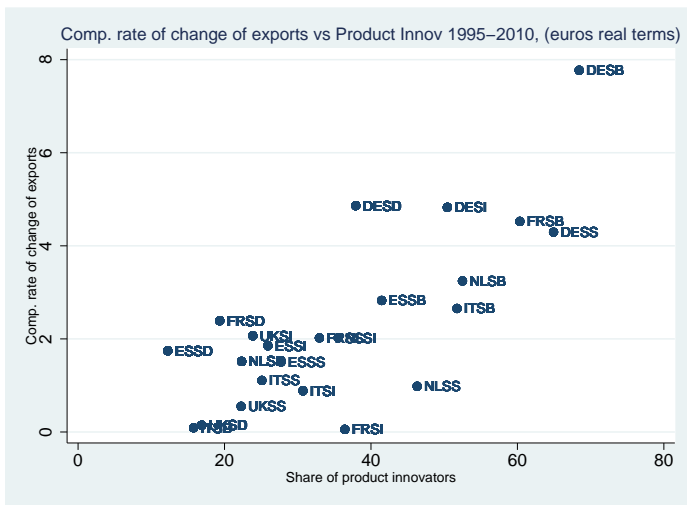
Data and Descriptive Evidence

Fig.1: R&D Expenditure vs Product Innovation
(Revised Pavitt categories, Bogliacino & Pianta 2015)



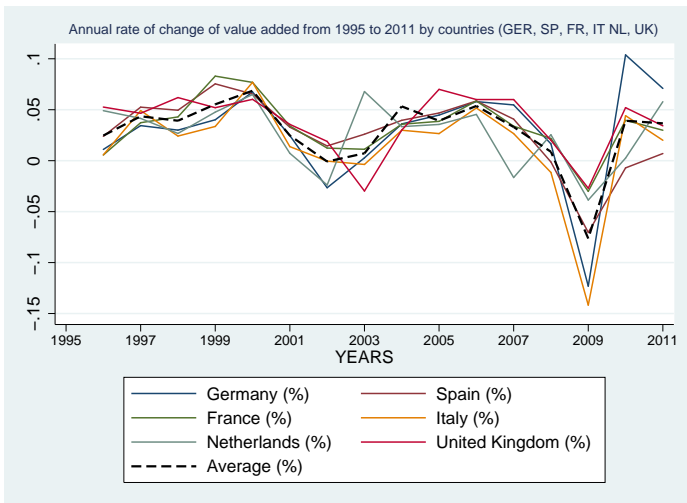
Data and Descriptive Evidence

Fig.2: Product Innovation vs Exports
(Revised Pavitt categories, Bogliacino & Pianta 2015)



Data and Descriptive Evidence

Fig.3: The dynamics of economic activity between 1995 and 2011
(Log diffs of Value Added at 2000 prices; Ger, Sp, It, Fr, NI, Uk)



The econometric strategy

- **Time structure:**

- ① Economic variables: comp. average annual rate of variation (96-00, 00-03, 03-07, 07-10)
- ② Innovation variables: expenditure/employee and share of firms (four waves from CIS2 (1996) to CIS6 (2010))

- **Strategy:**

- ① Weighted least squares and IV-OLS estimation equation by equation
- ② Robust standard errors to account for heteroskedasticity
- ③ 3SLS estimation of the three equation system (combining IV and SUR est. technique, allowing for disturbances cross correlation)
- ④ Interaction terms technique to analyze the coefficients' significance, direction and magnitude for different sub-samples
- ⑤ Excluded instruments: lagged R&D and Value Added; country, time and Pavitt dummies

- **Test:**

- ① Multicollinearity (Variance Inflation Factor)
- ② Heteroskedasticity (Breusch-Pagan test)
- ③ Endogeneity (Wooldridge, Hansen J-test)

3SLS estimation: The relationships between R&D, New Products and Export Market Shares

(Std. errors in brackets, country and Pavitt dummies, excl. inst: lag R&D, lag VA, country, time and Pav dummies)

	(1)	(2)	(3)
	R&D exp.	Prod. Inno	Exp Mkt Sh
L.R&D	0.68*** (0.05)	2.15*** (0.42)	
SIZE	0.93 (0.79)	23.38*** (5.06)	
DF	-0.05 (0.03)		
L.PROF	-0.01 (0.01)		
L.XMS	5.90*** (1.23)		
L.PROD-INNOV			0.003*** (0.00)
D.DEM		-0.92*** (0.20)	
EXP		4.58*** (1.07)	
L.EXMCHE		4.64*** (0.67)	0.022*** (0.00)
LAB. COST			-0.04*** (0.001)
IMP.INP(ht)			0.003 (0.00)
IMP.INP(lt)			-0.001 (0.00)
<i>N</i>	262	262	262

The 3SLS estimations: interpretation of the results

- **Feedback loop between R&D \Rightarrow Prod. Innov. \Rightarrow Exp. mkt share**
- R&D efforts are cumulative (lagged R&D), supported by lagged export market shares
- Innovative outcomes are driven by technological competitiveness strategies and by the growth of exports (the most dynamic component of demand following the *learning by exporting* thesis, *Crespi et al. 2007*); complementarity between product and process innovation holds (coherently with *Bogliacino & Pianta, 2013*)
- Export market shares positively affected by product, process innovation and negatively by Unit Labour Cost. Imported intermediate inputs are not significant at this stage

Does the 'virtuous circle' hold for any place, time or cluster of industries?

- **Interaction terms technique - no loss of observations - to estimate (different slopes and intercepts for each sub-sample) the impact of:**
 - 1 Up (1996-2000 & 2003-2007) and Downswings (2000-2003 & 2007-2010) of business cycles
 - 2 North (GER, NL, UK) vs Southern (IT, ES, FR) EU countries
 - 3 Manufacturing (From Sector 15 to 36, NACE Rev. 1 Cl.) vs Services (From 50 to 74, NACE Rev. 1 Cl.)
 - 4 High Tech (Science based and Specialized Suppliers) vs Low Tech (Scale Intensive and Supplier Dominated)

The impact of business cycles, country and technology clusters on R&D efforts

- 3SLS estimations with robust std. errors, interaction terms and excluded instruments. $N = 282$; Std. Errors in brackets, * Significant at 10%, ** Significant at 5%, *** Significant at 1%.

Coeff.	Up	Down	North	South	Man.	Serv.	HT	LT
$\beta_{L.R\&D}$	0.71*** (0.01)	0.65*** (0.01)	0.68*** (0.05)	0.67*** (0.08)	0.61*** (0.05)	0.70*** (0.12)	0.50*** (0.06)	0.80*** (0.10)
β_{Size}	4.92*** (0.01)	0.16 (0.82)	6.96*** (2.33)	0.21 (0.80)	8.55*** (2.18)	0.14 (0.82)	6.80*** (2.40)	0.01 (0.76)
β_{Front}	-0.16*** (0.04)	-0.01 (0.06)	-0.05 (0.04)	-0.07 (0.06)	-0.05 (0.03)	-0.05 (0.05)	-0.15*** (0.01)	0.01 (0.04)
β_{Prof}	-0.01 (0.02)	-0.01 (0.02)	-0.05 (0.04)	0.01 (0.01)	-0.02 (0.01)	-0.01 (0.02)	-0.02 (0.02)	-0.01 (0.01)
β_{Expsh}	7.78*** (1.86)	5.69*** (1.65)	4.76*** (2.05)	4.72** (2.13)	4.77*** (1.62)	3.81* (3.81)	12.10*** (2.19)	2.25* (1.36)

The impact of business cycles, country and technology clusters on **New Products**

- 3SLS estimations with robust std. errors, interaction terms and excluded instruments. $N = 282$; Std. Errors in brackets, * Significant at 10%, ** Significant at 5%, *** Significant at 1%.

Coeff.	Up	Down	North	South	Man.	Serv.	HT	LT
$\beta_{L.R\&D}$	0.60*** (0.40)	2.81 (0.56)	1.39*** (0.05)	1.02*** (0.08)	1.57*** (0.35)	2.55*** (0.81)	1.21*** (0.35)	1.97*** (0.81)
β_{Size}	45.00*** (12.09)	16.00*** (4.89)	20.00*** (4.56)	34.00*** (15.06)	34.62* (17.73)	16.84*** (5.05)	59.00*** (15.41)	20.00*** (5.02)
β_{Exp}	5.14*** (1.56)	3.86*** (1.23)	4.84*** (1.27)	10.73*** (1.78)	4.86*** (1.22)	46.63*** (12.43)	6.30*** (1.33)	2.88* (1.59)
β_{DDem}	0.19 (0.26)	-1.11* (0.24)	-0.35 (0.23)	-0.49* (0.24)	-0.66*** (0.19)	1.55*** (0.46)	-0.38*** (0.02)	-0.32*** (0.01)
$\beta_{Proc.Inn}$	2.97*** (1.39)	10.07*** (0.68)	2.97*** (0.80)	10.07** (1.02)	4.35*** (0.71)	4.00*** (2.02)	4.30*** (0.94)	5.81*** (0.86)

The impact of business cycles, country and technology clusters on **Export Market**

Shares

- 3SLS estimations with robust std. errors, interaction terms and excluded instruments. $N = 282$; Std. Errors in brackets, * Significant at 10%, ** Significant at 5%, *** Significant at 1%,

Coeff.	Up	Down	North	South	Man.	Serv.	HT	LT
$\beta_{Newprod}$	0.002*** (0.00)	0.003*** (0.00)	0.005*** (0.00)	0.002*** (0.00)	0.003*** (0.00)	0.003*** (0.00)	0.003*** (0.00)	0.003*** (0.00)
$\beta_{ProcInn}$	0.01 (0.00)	0.02* (0.00)	0.006 (0.00)	0.14* (0.00)	0.01*** (0.00)	0.02 (0.00)	0.008 (0.00)	0.02*** (0.00)
β_{ULC}	-0.004*** (0.04)	-0.006 (0.06)	-0.007*** (0.00)	-0.01 (0.00)	-0.002 (0.00)	-0.009*** (0.00)	-0.002 (0.01)	-0.005*** (0.04)
$\beta_{Offsh(ht)}$	0.003 (0.00)	0.002 (0.00)	0.002 (0.00)	0.004 (0.00)	0.004*** (0.00)	-0.004 (0.00)	0.001 (0.00)	0.002 (0.00)
$\beta_{Offsh(lt)}$	0.004*** (0.00)	-0.002* (0.00)	0.00 (0.00)	-0.002 (0.00)	-0.002 (0.00)	0.007 (0.00)	0.001 (0.00)	0.002 (0.00)

Conclusions, novelties and final remarks

- **The impact of business cycle, country groups, manufacturing/services and technological clusters (summary of the main results):**
 - 1 **UP vs DOWNSW:** Imitation (Dist. from the frontier) and firms' size are relevant only during Upswings while Process Innovation (restructuring) is stronger during Downswings; 'Demand push' and the negative impact of ULC are stronger during Upswings
 - 2 **NORTH vs SOUTH:** R&D is more likely to be concentrated in big firms in the 'North' while complementarity with Process Innovation is there only for the South
 - 3 **MANUF vs SERVICES:** Imported high-tech intermediate inputs push Manufacturing sectors' exports while low tech intermediate inputs have a positive impact for the service sector
 - 4 **HTECH vs LTECH:** Both imitation (distance from the frontier) and 'demand pull' (exports) effects hold only for high tech sectors (confirming Dosi et al., (2014) results)

Conclusions, novelties and final remarks

- **Strengthening and extending the conceptual and methodological framework proposed by Crepon et al. (1998) and Bogliacino & Pianta (2013):**
 - 1 Relevance of the distinction between technology and cost competitiveness
 - 2 Disentangled the different behaviors of demand components (role of exports) as drivers of innovative performances
 - 3 Highlighted the importance of the link between innovation and international performance
 - 4 Complementarity between product and process innovation
 - 5 The same system of complex relations assumes alternative patterns considering different sub-samples