Technology, wages and profits in European industries

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Introduction

- This work is based on Coveri & Pianta, *The Structural Dynamics of Income Distribution: Technology, Wages and Profits*, WP Univ. of Urbino no. 2019/01, and builds on Pianta & Tancioni (2008, JPKE)
- We focus on the **distributional dynamics** of European industries providing an empirical analysis of the structural determinants which shape the **capital-labour conflict** and thereby the functional distribution of income in the age of **globalization** (Rodrik, 1997).
- We provide evidence about the impact of different kinds of **innovation** (Pianta & Tancioni, 2008), the growing **international fragmentation of production** (Feenstra, 1998) and the labour market institutions (**union density**) on the workers' bargaining power and thus profit and wage dynamics.
- **Industry-level analysis**: the Sectoral Innovation Database.

Motivation

- Since the end of the Seventies a series of technological and structural factors – together with a major turning point in economic policy – have occurred by favoring capital over labour income and exacerbating disparities (Atkinson et al., 2011; Franzini and Pianta, 2016; Glyn, 2006; Piketty and Saez, 2003)

  → long-term decline of the labour share of income

- Connection between functional and personal income distribution:

  functional income distribution, i.e. inter-class inequality, is a key explanatory determinant of personal distribution of income (Daudey and Garcia-Penalosa, 2007; Wolff and Zacharias, 2013) and it is thus an element of major relevance to understand current income inequality (Atkinson, 2009).

Neoclassical (marginalist) theory of distribution

- **Harmonious** conception of income distribution, i.e. analytical view such that there is no conflict between capitalists and workers given that – market "imperfections" and "failures" aside – each "factor of production" is remunerated according to its marginal productivity

- Main determinants of income distribution detected:
  - **technological change**: ICTs + robotic and automation = capital-biased technological change → decline in the price of capital relative to labour and a process of replacing workers (in particular those who perform routine jobs as they are more easily automatized) with machines (Acemoglu and Restrepo 2017, 2018) → increase in the capital-output ratio, which in turn reduces the labour share to the extent that the elasticity of substitution between capital and labour is found to be larger than one (e.g. Bassanini & Manfredi, 2014; Karabarbounis and Neiman, 2014).

- **globalization**: capital-abundant countries offshore labour-intensive tasks in labour-abundant countries → growing capital-output ratio in the former countries and – whether capital acts as a gross substitute for labour – in a declining labour share (Bassanini and Manfredi, 2014; European Commission, 2007; IMF, 2017).

- **technology + trade liberalization**: the former may be induced by the latter: the opportunity cost of introducing innovation falls as a consequence of trade liberalization with a low-wage country (e.g. China) and their empirical results suggest that sectors more exposed to the Chinese import competition increased technical change (see Bloom et al., 2013, 2016).

- **"Superstar firms"**: increased market concentration allows these firms to rise the mark-up reducing the wage share (within-firm effect) (see Autor et al., 2017)

(see also Bentolila & Saint-Paul, 2003; OECD, 2018)

Post-Keynesian theory of distribution

- **Conflictual** nature of wage and profit setting (Harcourt, 2006; Lavoie, 2014)
- Major emphasis on the **shift in the balance of power between capital and labour**, favoring the former at the expense of the latter, occurred in the last four decades → so-called 'Neoliberalism'

  → the change of paradigm in economic policy occurred in the Eighties, which led to new institutional arrangements harmful to workers: welfare state retrenchment, sharp reduction of union density and collective bargaining coverage, reduction of employment protection legislation, spread of fixed-term jobs and precarious work (Bengtsson, 2014a; Charpe, 2011; Stockhammer, 2009, 2013)

- According to this theoretical perspective, a strong employment protection legislation are not primarily responsible for the level of employment, but they are key factors which shape fundamentally the workers' bargaining power and thus the share of national income the workers earn (Brancaccio et al., 2018; Stockhammer et al., 2014; see also Dosi et al., 2017)

- Other relevant drivers:
  - **globalization** favored the most mobile (rather than the most abundant) production factor, i.e. capital, and supported offshoring practices aimed at reducing labor costs (Jayadev, 2007; Rodrik, 1997; Stockhammer, 2017).
  - **financialization** enhanced the fall-back options of capital and increased the shareholder value orientation of firms, with major consequences in terms of corporate governance and workers' bargaining capacity (Dunhaupt, 2016; Kohler et al., 2018; Lin and Tomaskovic-Devey, 2013).
  - recently also **technological change** (e.g. Guschanski and Onaran, 2017, 2018; Stockhammer, 2017)

- Guschanski and Onaran (2017) find that offshoring (mainly to emerging countries and Eastern Europe) has a strong negative impact on the wage share within sectors, together with the welfare state retrenchment, the decrease of union density and the overall rise in inequality; technological change (proxied by TFP) and (ICT) capital intensity have a significant and negative impact on the labour share until the mid-Nineties

Theoretical approach

- We combine a **Neo-Schumpeterian approach** to the dynamics of innovation and technological change with a **Post-Keynesian view** of income distribution, accounting for the **international fragmentation of production** along GVCs.

- Previous relevant studies:
  - Van Reenen (1996)'s "rent sharing" model: if the bargaining power of workers is strong enough, wages could also benefit from the extra rents (profits) stemming from the introduction of new products.
  - Pianta & Tancioni (2008): profits are driven both by product and process innovation while wages grow faster in technology-based sectors (because strategies of cost competitiveness tend to be aimed at job destruction and wages reduction), although a meaningful heterogeneity emerges when they distinguish high- and low- innovation industries.
  - Bogliacino (2009) and Bogliacino et al. (2018) found respectively that (a) wages increase in industries characterized by product innovation, while process innovation is associated to a reduction of real wages; (b) R&D expenditure exerts a positive effect on wages while offshoring a negative one.

Evolutionary theory of innovation

- **Schumpeterian concept** of «creative destruction» (Schumpeter, 1934, 1939) and «creative accumulation» (Schumpeter, 1942) strictly linked to the process of **dynamic competition**

➢ innovations allow the profit-seeking innovator to overcome competitors: **"rent"** no longer conceived as deadweight welfare loss but as the economic **outcome of dynamic competition**.

➢ *capitalism is an evolutionary process of continuous innovation*

→ Marxian vision of capitalistic competition, at odds with both the Classical-Ricardian and Neoclassical-Walrasian one

- Knowledge advancements come out through the emergence of **technological paradigms** (or "techno-economic paradigms"): clusters of radical innovations that drive technological change (Dosi, 1982, 1988; Rosernberg, 1982).

- **Path dependent** nature of technological change (Nelson & Winter, 1982; Dosi, 1984; Freeman & Louca, 2001) and increasing returns due to dynamic economies of scale (Sylos Labini, 1967).

The role of technological change

- Schumpeterian distinction between technological competitiveness (new products) and cost competitiveness (new processes) (Pianta, 2001):

➢ **Product innovation**: search for quality improvements, high internal innovative efforts and a propensity to innovate for opening new markets consistently with the evolution of demand

→ technology-driven competitiveness strategy

➢ **Process innovation**: high machinery expenditures, propensity to acquire new technologies from suppliers, augment the mechanization degree of production processes, introduce labour-saving technologies and search for increased flexibility

→ cost-based competitiveness strategy

- While at the firm level these strategies might coexist, at the industrial level it is possible to identify the dominant strategy.
- Previous works: Bogliacino, 2009; Bogliacino and Pianta, 2010, 2011; Bogliacino et al., 2018; Cirillo, 2017; Crespi and Pianta, 2007, 2008; Vivarelli & Pianta, 2000.

The role of offshoring

- Trade liberalization policies, collapse of transport and communication costs led to an intensification of trade flows of **intermediate inputs → international fragmentation of production** & rise of **Global Value Chains** (GVCs) (Feenstra, 1998; Hummels et al., 2001; Milberg & Winkler, 2013)
- **Offshoring strategies** and potential consequences on industries' performance (Grossman and Rossi-Hansberg, 2008; Timmer et al., 2014):
  - knowledge-based upgrading of firms' productive system;
  - price reductions through the acquisition of cheap foreign intermediate inputs
  - indirect access to foreign final markets (FDIs);
  - taking advantage of international technological spillovers which foster skill and organizational upgrading and dynamic returns to scale (Campa and Goldberg, 1997; Colantone and Crinò, 2014; Stollinger, 2017);
  - production delocalization can lead to a contraction of the industry with consequent job losses (Bramucci et al., 2017; Stollinger 2016);
  - low-tech offshoring strategies might undermine innovative efforts and technological upgrading, leading to phenomena of technological lock-in (industries stuck in low-value added productions) and market shares reductions.

An industry-level analysis

- **Sectoral systems of innovation**: innovative behaviour of firms is crucially affected by the fundamental features (in terms of opportunity, appropriability, cumulativeness and knowledge base) of the technological regime of the industry they belong to (Breschi et al., 2000; Malerba and Orsenigo, 1997; Malerba, 2002).

- Pavitt (1984) identifies four different classes of industries for the manufacturing sector in terms of market structure and nature, source and appropriability of innovation.

- Bogliacino and Pianta (2010, 2016): extend to services the Pavitt taxonomy on the basis of their technological patterns and on the relationships between innovation and economic performance → **Revised Pavitt Classes** (RPC) (*see Appendix*).

Key determinants of income distribution dynamics

1. **Labour productivity**: major driver of industries' growth and decline (Pasinetti, 1981), representing a factor which captures both the growth of *capital investment* and *value added*, as well as the *organizational improvements* carried out by industries (Pianta and Tancioni, 2008). A robust labour productivity growth provides room to boost both profits and wages.

2. **Product innovation** (tech.-driven competitiveness strategy): expected to spur both profits and wages
   - allows to intercept a changing demand
   - relies more on an environment which favors cooperation among workers within firms (facilitating search procedures, taking advantage of employees' cumulative knowledge and favoring their skill upgrading)
   - Van Reenen (1996)'s "rent sharing" model: if the bargaining power of workers is strong enough, wages could also benefit from the "extra-rents" (profits) stemming from the introduction of new products (see also Buchele and Christiansen, 1999; Cantwell, 2005; Kleinknecht et al., 2016).

3. **Process innovation** (cost-based competitiveness strategy): expected to be
   - positive for profits – it enables increasing productive efficiency and price reductions of firm's goods
   - detrimental for wages – it may imply the expulsion of workers from the production process (or accredit the firing threat) narrowing their bargaining power (Bogliacino, 2009; Cirillo, 2017; Vivarelli, 2014).

4. **Union density**: proxy of the bargaining position of workers (limited availability of industry-level data)

- more unionized industries are expected to be the ones with wider coord. collective bargaining and pro-labour and social standards more binding (Bengtsson, 2014; Jaumotte and Buitron, 2015; OECD, 2018). Pontusson (2013) finds a weaker relation between union density and income inequality since the early Nineties (changing member composition of Tus and softening of the solidarity character of unions' wage claims);
- insofar as unions are able to monitor the unfolding of the working process – e.g. ensuring respect for the safety conditions of workers in the workplace with the aim of protecting their welfare and minimizing occupational accidents –, the "rigidities" within the production process become more binding and the monitoring and organizational costs for firms are likely to rise negatively affecting profits.

5. **Offshoring** potentially impacts on profits and wages through a…
   - **cost channel**:
     - inflow of cheap intermediate inputs; lower cost due to weak employment protection, fiscal and environmental regulations (race-to-the-bottom dynamics) (Feenstra, 1998; Rodrik, 1997; Stockhammer, 2017);
     - dismission of domestic productions and laying off of workers (credible threat against workers' claims) (Burke and Epstein, 2001; Choi, 2001; Kramarz, 2017).
   - **technological channel**:
     - firms gain competitiveness thanks to new supply sources of not-domestically produced good;
     - the knowledge content of intermediate inputs flows;
     - the occurrence of technological spillovers and the stimulus towards organizational innovation (Campa and Goldberg, 1997; Colantone and Crinò, 2014; Hummels et al., 2018; Pöschl et al., 2016);
     - ➢ High-tech offshoring could entail a general knowledge-based upgrading of firms' productive system, enhancing domestic workers' complementary skills with a positive impact on their remuneration. On the other hand, it may be the hint of a technological dependence along the GVC (Lucarelli and Romano, 2016) → impact of high-tech offshoring on wage growth is theoretically ambiguous.

The Sectoral Innovation Database (SID)

- Initially developed at the University of Urbino (Pianta et al., 2014) the SID enables to **move beyond the notion of an undifferentiated technological change** proxied by R&D or patents
  - R&D and patents are poor proxies of the technological activity carried out in firms outside science based sectors; R&D does not account for innovative activities linked to design, engineering and new processes; patents are a rough proxy of innovation as not all inventions are patented and have the same economic relevance; patenting is often not available for the innovations of most service industries (Archibugi and Pianta, 1996)

- The SID combines **five sources** of data:
  - Community Innovation Surveys (CIS) from Eurostat
  - Labour Force Survey (LFS) from Eurostat
  - OECD-Structural Analysis database (OECD-STAN)
  - World Input-Output Database (WIOD)
  - ICTWSS database

- Industry level data, available at the two-digit NACE (Rev. 1) classification for **21 manufacturing and 17 service sectors** (overall: 38 sectors)

- **Six major European countries**: Germany, France, Italy, Spain, the Netherlands, the UK (75% of EU28's GDP)

- Time span: **1994 – 2014**

- The **innovation variables** are drawn the following European Community Innovation Surveys:
  - ✓ CIS 2 (1994-1996)
  - ✓ CIS 3 (1998-2000)
  - ✓ CIS 4 (2002-2004)
  - ✓ CIS 7 (2008-2010)
  - ✓ CIS 9 (2012-2014)
- **Economic variables** are drawn from the Social Economic accounts provided by the World Input-Output Database (WIOD) and from the OECD-STAN database.
- **Offshoring variables** (broad, narrow, high- and low-tech offshoring indicators) have been constructed exploiting WIOD (Feenstra & Hanson, 1996, 1999; Guarascio et al., 2015)
- **Labour market variables** on temporary/permanent and full-/part-time jobs and ISCO classification of occupation (Managers, Clerks, Craft and Manual workers) are drawn from the Labour Force Survey (Eurostat).
- Data on **union density** at industrial level are drawn from the ICTWSS database.

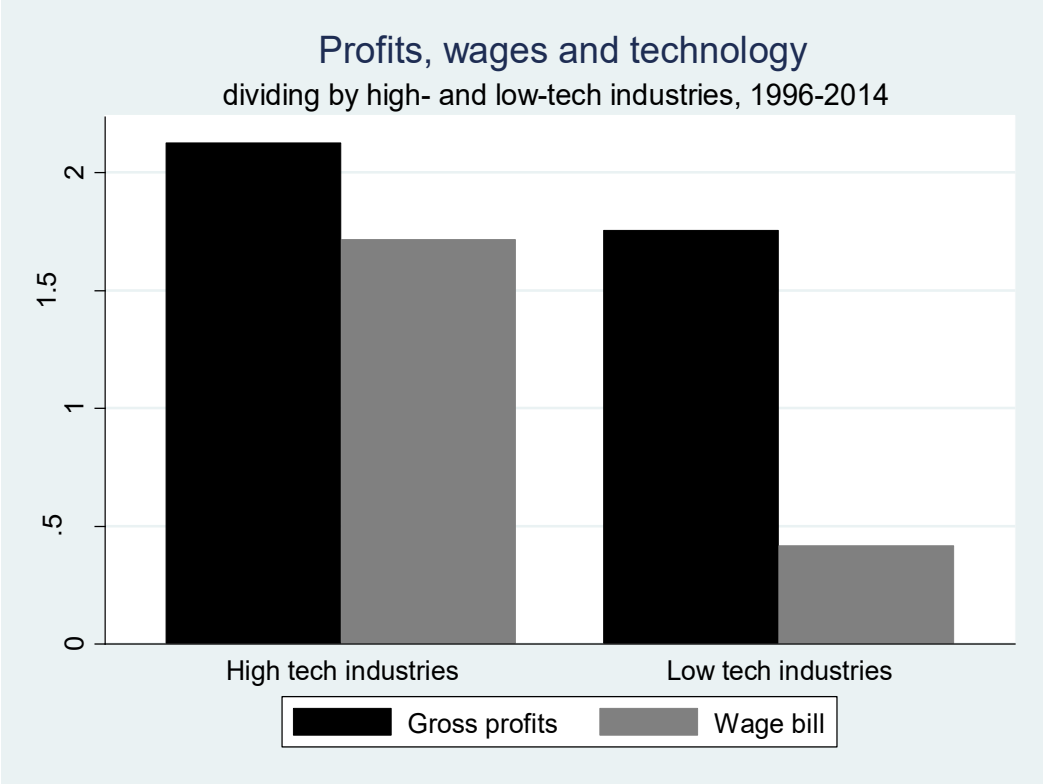
All data have been converted into euros and constant prices; economic variables are deflated using the sectoral Value Added deflator from WIOD and corrected for PPP (using the index provided in Stapel et al., 2004).

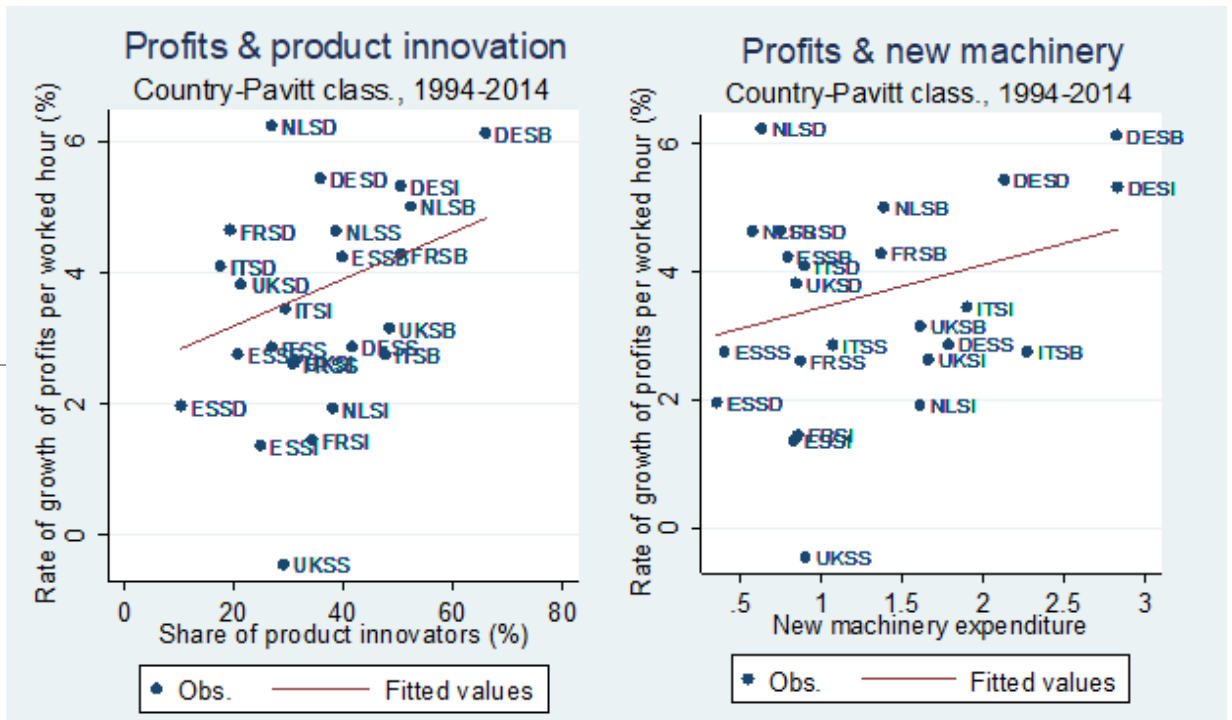
Time structure of the panel

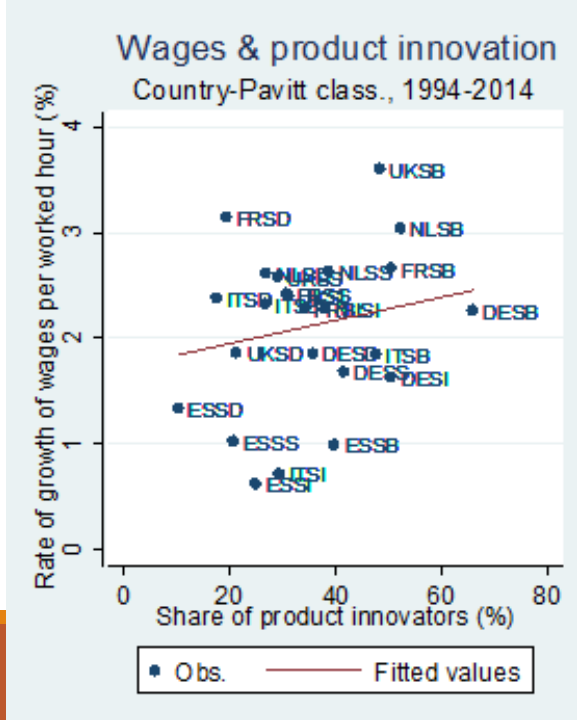
Innovation variables refer to:

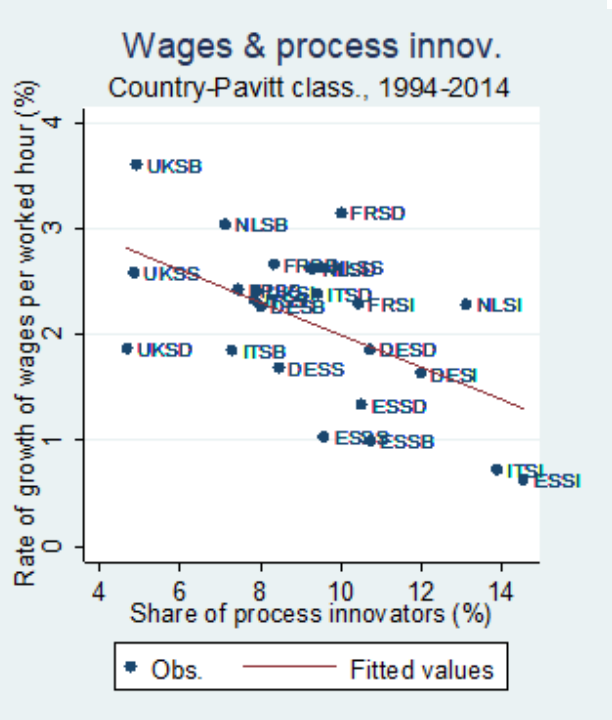
- 1994–1996
  - linked to the first period of economic variables: 1996-2000;
- 1998–2000
  - linked to the second period of ec. variables: 2000-2003;
- 2002–2004
  - linked to the third period of ec. Variables: 2003-2008;
- 2008–2010
  - linked to the fourth period of ec.variables: 2008-2012;
- 2012–2014
  - linked to the fifth period of ec. variables: 2012-2014.

Descriptive evidence: *Technology*



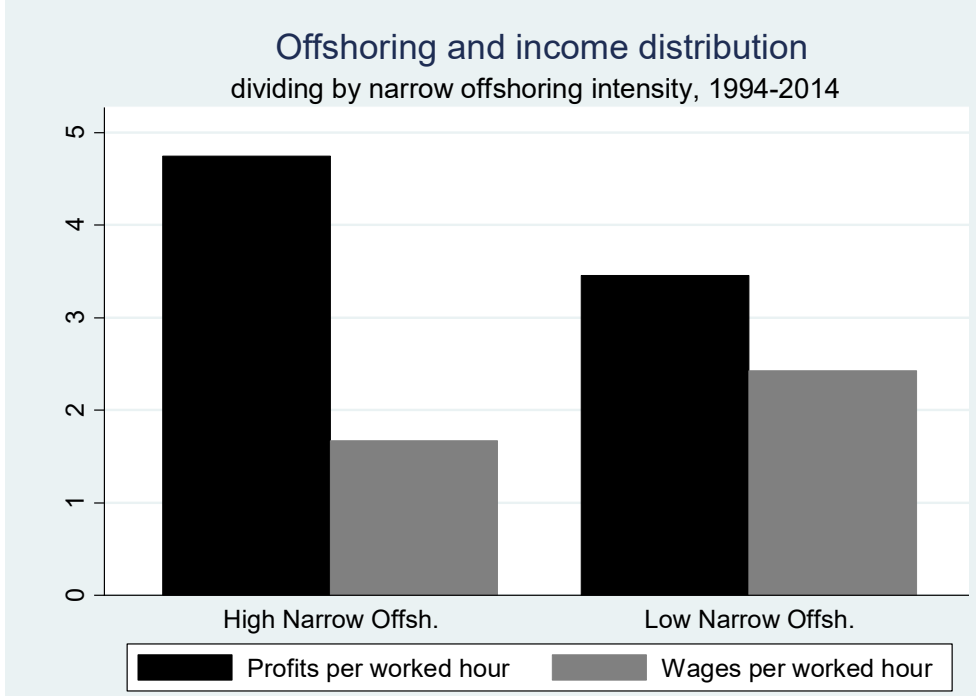


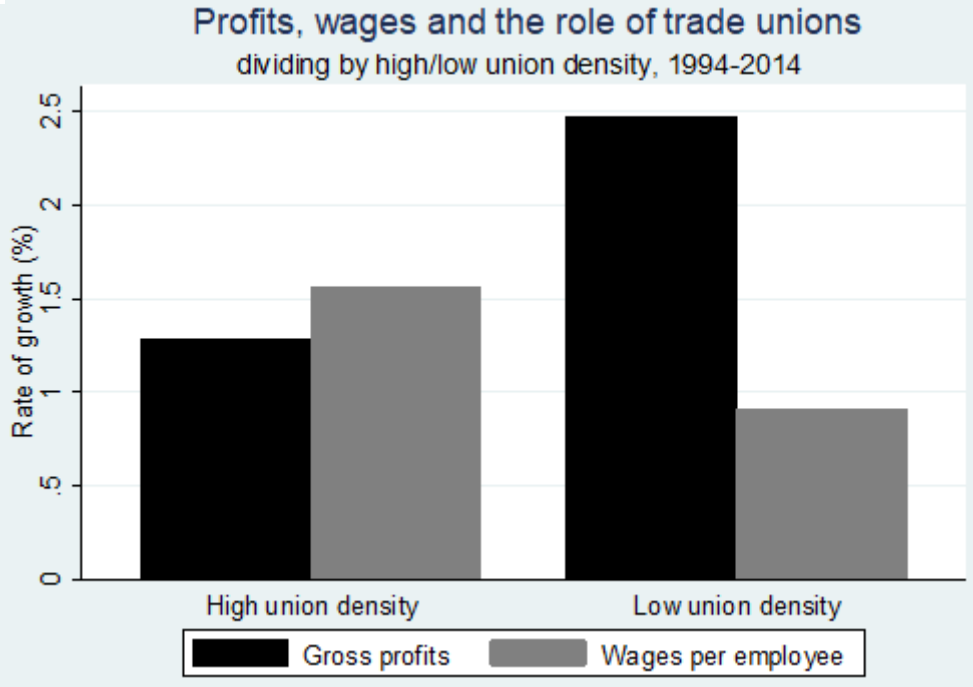


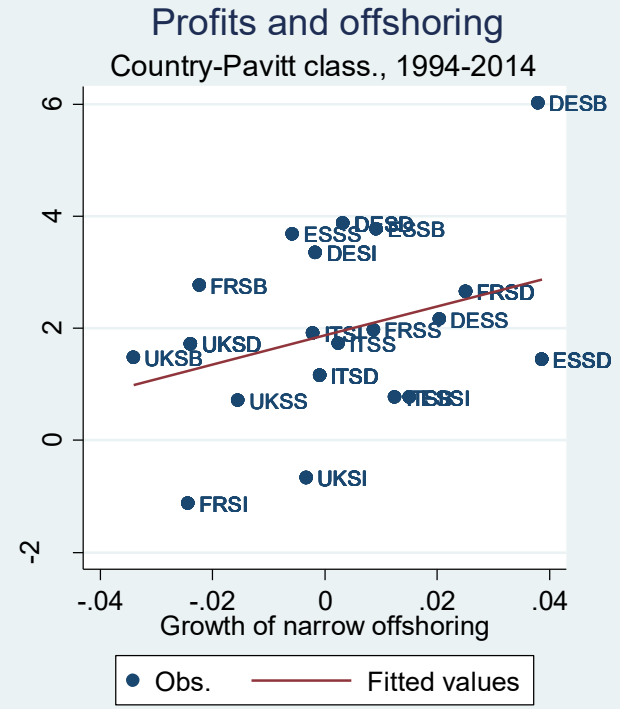


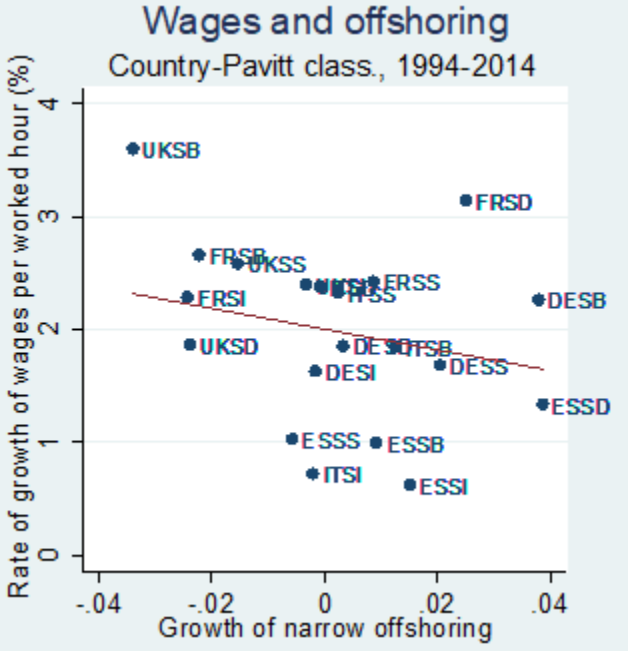
Offshoring

Union density









A simultaneous model

The wage equation

$$\Delta\log(W_{ijt}) = \alpha_1\Delta log(PROF_{ijt}) + \alpha_2\Delta log(PRODUCTIVITY_{ijt}) + \alpha_3\Delta log(Prod.Innov_{ijt}) + \alpha_4\Delta log(Proc.Innov_{ijt}) + \alpha_5\Delta log(OFFSH_{ijt}) + \alpha_6\Delta log(UnionDensity_{ijt}) + \Delta\varepsilon_{ijt}$$

dependent variable: compound average annual growth rate (log difference) of wage per worked hour

The profit equation

$$\Delta log(PROF_{ijt}) = \alpha_1\Delta log(W_{ijt}) + \alpha_2\Delta log(PRODUCTIVITY_{ijt}) + \alpha_3\Delta log(Prod.Innov_{ijt}) + \alpha_4\Delta log(Proc.Innov_{ijt}) + \alpha_5\Delta log(OFFSH_{ijt}) + \alpha_6\Delta log(UnionDensity_{ijt}) + \Delta\varepsilon_{ijt}$$

dependent variable: compound average annual growth rate (log difference) of gross profits

Econometric strategy

- **First difference** of the equation – in log scale – to eliminate time invariant effects, soften the time dimension and address the endogeneity problem;
- **Long differences**, computed over two- to five-year periods, considerably reducing the autoregressive character (and the implied endogeneity) of the models;
- Innovation variables always refer to a **lagged period** as compared to the dependent variable, reducing the presence of simultaneity-related endogeneity and accounting for the time required by our innovation proxies to impact on the distributive components;
- Time, country and Pavitt **dummies**, reducing the endogeneity bias which may stem from other sources of observable heterogeneity;
- Weighted Least Squares (**WLS**) estimations (sector- and time-specific number of employees as weights, not affected by prices as value added) with **robust** standard errors and Seemingly unrelated regression estimator (**SURE**)
  - the latter exploits correlation among regression equations' residuals to gain efficiency (Zellner, 1962) – since industries' evolution is shaped fundamentally by their technological regimes and institutional setting, common factors impacting simultaneously on both dependent variables may occur, affecting in this way regressions' stochastic disturbances;
- **Other robustness checks:** different proxy for product innovation; controls related to industries' employment structure (share of managers and of manual workers based on ISCO categories).

	(1) ΔWages	(2) ΔWages	(3) ΔWages	(4) ΔWages	(5) ΔWages	(6) ΔWages
ΔProfits	-0.0410***	-0.0421***	-0.0373**	-0.0420***	-0.0400***	-0.0437***
	(0.0142)	(0.0143)	(0.0146)	(0.0151)	(0.0146)	(0.0152)
Share of firms introducing product innovation	0.00901	0.00957	0.0199**	0.0247***	0.0226***	0.0258***
	(0.00655)	(0.00722)	(0.00780)	(0.00896)	(0.00793)	(0.00913)
Expenditure in new mach. and equipment per emp.	-0.321**	-0.278**	-0.279**	-0.197	-0.278**	-0.217
	(0.127)	(0.137)	(0.133)	(0.148)	(0.132)	(0.146)
ΔProductivity	0.524***	0.521***	0.514***	0.514***	0.508***	0.508***
	(0.0492)	(0.0514)	(0.0499)	(0.0520)	(0.0500)	(0.0524)
Union density			0.0288**	0.00907	0.0277**	0.0108
			(0.0114)	(0.0198)	(0.0113)	(0.0199)
ΔNarrow offshoring			-0.250***	-0.238***		
			(0.0872)	(0.0845)		
ΔOffshoring HT					-0.184*	-0.186*
					(0.103)	(0.105)
ΔOffshoring LT					-0.196**	-0.200**
					(0.0886)	(0.0871)
Time dummies	Yes***	Yes***	Yes***	Yes***	Yes***	Yes***
Manufacturing dummy	No	No	Yes**	Yes**	Yes**	Yes**
Pavitt dummies	No	Yes	No	Yes**	No	Yes**
Country dummies	No	Yes	No	Yes	No	Yes
F-test Pavitt & country dummies	-	0.1694	-	0.4102	-	0.3653
Observations	845	845	833	833	831	831
R-squared	0.505	0.516	0.519	0.528	0.522	0.532

	(1) ΔProfits	(2) ΔProfits	(3) ΔProfits	(4) ΔProfits	(5) ΔProfits	(6) ΔProfits
ΔWages	-0.270***	-0.272***	-0.244***	-0.269***	-0.267***	-0.284***
	(0.0890)	(0.0875)	(0.0938)	(0.0930)	(0.0941)	(0.0938)
Share of firms introducing product innovation	0.0562**	0.0403	0.0626**	0.0541*	0.0628**	0.0536
	(0.0272)	(0.0293)	(0.0266)	(0.0313)	(0.0284)	(0.0332)
Expenditure in new mach. and equipment per emp.	0.277	0.390	0.494	0.628	0.507	0.667
	(0.735)	(0.755)	(0.752)	(0.773)	(0.763)	(0.783)
ΔProductivity	0.404***	0.433***	0.402***	0.427***	0.414***	0.433***
	(0.103)	(0.103)	(0.105)	(0.102)	(0.108)	(0.106)
Union density			-0.0227	0.00166	-0.0199	0.00621
			(0.0334)	(0.0541)	(0.0334)	(0.0547)
ΔNarrow offshoring			0.821***	0.787***		
			(0.253)	(0.254)		
ΔOffshoring HT					0.547*	0.549*
					(0.282)	(0.283)
ΔOffshoring LT					-0.0714	0.0172
					(0.187)	(0.189)
Time dummies	Yes***	Yes***	Yes***	Yes***	Yes***	Yes***
Manufacturing dummy	No	No	Yes*	Yes**	Yes	Yes**
Pavitt dummies	No	Yes***	No	Yes***	No	Yes***
Country dummies	No	Yes***	No	Yes*	No	Yes*
F-test Pavitt & country dummies	-	0.0002	-	0.0003	-	0.0004
Observations	845	845	833	833	831	831
R-squared	0.109	0.146	0.132	0.170	0.123	0.163

	(1) SURE		(2) SURE		(3) SURE	
	ΔProfits	ΔWages	ΔProfits	ΔWages	ΔProfits	ΔWages
ΔWages	-0.516***		-0.555***		-0.637***	
	(0.0829)		(0.0833)		(0.0829)	
ΔProfits		-0.0876***		-0.0935***		-0.107***
		(0.0141)		(0.0140)		(0.0140)
Share of firms introducing product innovation	0.0998***	0.0353***	0.101***	0.0373***	0.119***	0.0430***
	(0.0187)	(0.00774)	(0.0191)	(0.00788)	(0.0205)	(0.00846)
Expenditure in new mach. and equipment per emp.	-0.0842	-0.132	-0.0553	-0.101	0.168	0.0216
	(0.248)	(0.102)	(0.252)	(0.103)	(0.263)	(0.108)
ΔProductivity	0.506***	0.321***	0.524***	0.322***	0.509***	0.311***
	(0.0581)	(0.0224)	(0.0586)	(0.0225)	(0.0587)	(0.0227)
Union density	0.0122	0.0345***	0.0154	0.0325***	-0.0108	0.00202
	(0.0279)	(0.0114)	(0.0279)	(0.0114)	(0.0450)	(0.0185)
ΔNarrow offshoring	0.398***	-0.115*				
	(0.147)	(0.0607)				
ΔOffshoring HT			0.130	-0.127*	0.0919	-0.133*
			(0.175)	(0.0716)	(0.175)	(0.0715)
ΔOffshoring LT			0.135	-0.0570	0.121	-0.0661
			(0.138)	(0.0568)	(0.139)	(0.0570)
Time dummies	Yes***	Yes***	Yes***	Yes***	Yes***	Yes***
Manufacturing dummy	Yes***	Yes***	Yes**	Yes***	Yes***	Yes***
Country dummies	No	No	No	No	Yes	Yes***
Pavitt dummies	No	No	No	No	Yes***	Yes***
Observations	836	836	834	834	834	834
R-squared	0.141	0.327	0.135	0.329	0.162	0.350

Conclusions

- Strongly negative relationship between wage and profit dynamics (**capital-labour conflict**), shaped by the technological trajectories of industries and vertical disintegration of production process;
- Labour productivity growth drives both wages and profits;
- A **technological-driven strategy of competitiveness**, aimed to introduce new products and innovations to open up new markets, has a strong and significant positive effect on both profits and wages;
- A **cost-based competitiveness strategy** has the reduction of wages as main effect;
- The **offshoring processes** carry out by firms a) represent a reliable weapon to threaten the bargaining power of workers in advanced countries, reducing their wages (especially low-tech offshoring → 'race to the bottom'); b) support profits, especially high-tech offshoring:
  - industries that occupy a 'high position' in the hierarchical global value chains are able to catch the technological spillovers and take advantage of technical progress embedded in imported intermediate inputs, increasing their profits;
- Positive role of **trade unions** in balancing the negotiating power among capitalists and workers (i.e. labour market institutions matter in distributional dynamics)

Appendix

Baseline profit equation: endogeneity tests

Test	Endogenous variable	Instruments	Estimator	Test F (first stage) and overidentification tests	Final test (second stage) and endogeneity test	Result
Control function approach	**Productivity**	QCLE, QCWO, QMWO (same results with lagged SIZE as instrument)	WLS, robust s.e.	F(9, 719) = 147.14 Prob > F = 0.0000	Ho: variables are exogenous P-val > |t| = 0.37 (test on the residuals predicted in the first stage)	***exogenous***
Wooldridge's (1995) robust score test and robust regression-based test after 2sls	**Productivity**	QCLE, QCWO, QMWO	2SLS weighted, with robust s.e. (*ivregress 2sls* Stata's command)	F(10, 695) = 119.95 Prob > F = 0.0000 ——————— Test of overidentifying restrictions: Hansen's (1982) J statistic: Score chi2(1) = 0.738166 P-val = 0.6914	Tests of endogeneity Ho: variables are exogenous Wooldridge's (1995) robust score test = 0.613604 P-val = 0.4334 Robust regression-based test F(1,696) = 0.492114 P-val = 0.4832	***exogenous*** ***exogenous***
Wooldridge's (1995) robust score test and robust regression-based test after 2sls	**Productivity**	QMAN, QMWO, lagged RVA	2SLS weighted, with robust s.e. (*ivregress 2sls* Stata's command)	F(10, 598) = 128.92 Prob > F = 0.0000 ——————— Test of overidentifying restrictions: Hansen's (1982) J statistic: Score chi2(1) = 1.8427 P-val = 0.3980	Tests of endogeneity Ho: variables are exogenous Wooldridge's (1995) robust score test = 2.767 P-val = 0.0962 Robust regression-based test F(1,696) = 2.39478 P-val = 0.1223	**endogenous** ***exogenous***

The Revised Pavitt Taxonomy

(a) *Science-Based* industries (SB) include sectors where innovation is based on advances in science and R&D (such as the pharmaceuticals, electronics, computer services) where research laboratories are important, leading to intense product innovation and a high propensity to patent.

(b) *Specialised Supplier* industries (SS) include the sectors producing machinery and equipment; their products are new processes for other industries. R&D is present but an important innovative input comes from tacit knowledge and design skills embodied in the labour force. Average firm size is small and innovation is carried out in close relation with customers.

(c) *Scale and Information Intensive* industries (SI) include sectors (such as the automotive sector and financial services) characterised by large economies of scale and oligopolistic markets where technological change is usually incremental. New processes (often related to information technology) shape the organisation of production and coexist with new product development.

(d) *Supplier Dominated* industries (SD) include traditional sectors (such as food, textile, retail services) where internal innovative activities are less relevant, small firms are prevalent and technological change is mainly introduced through the inputs and machinery provided by suppliers from other industries.

Source: Bogliacino & Pianta (2010).

Science-based (SB) sectors

Chemicals; Office machinery; Manufacture of radio, television and communication equipment and apparatus; manufacture of medical, precision and optical instruments, watches and clocks; **Communications; computer and related activities; Research and development.**

Specialised suppliers (SS) sectors

Mechanical engineering; manufacture of electrical machinery and apparatus n.e.c.; manufacture of other transport equipment; **real estate activities; renting of machinery and equipment; other business activities.**

Scale and information intensive (SI) sectors

Pulp, paper & paper products; Printing & publishing; Mineral oil refining, coke & nuclear fuel; Rubber & plastics; non-metallic mineral products; basic metals; motor vehicles; **financial intermediation, except insurance and pension funding; insurance and pension funding, except compulsory social security; activities auxiliary to financial intermediation.**

Supplier dominated (SD) sectors

Food, drink & tobacco; textiles; clothing; leather and footwear; wood & products of wood and cork; fabricated metal products; furniture, miscellaneous manufacturing; recycling; **sale, maintenance and repair of motor vehicles and motorcycles; retail sale of automotive fuel; wholesale trade and commission trade, except of motor vehicles and motorcycles; retail trade, except of motor vehicles and motorcycles; repair of personal and household goods; hotels & catering; inland transport; water transport; air transport; supporting and auxiliary transport activities; activities of travel agencies.**

Source: Bogliacino & Pianta (2016).

Nr.	Sectors (Nace Rev. 1)	Nace codes	Revised Pavitt class	High-tech / Low-tech *
	Manufacturing sectors			
1	FOOD PRODUCTS, BEVERAGES AND TOBACCO	15-16	SD	LT
2	TEXTILES	17	SD	LT
3	WEARING APPAREL, DRESSING AND DYEING OF FUR	18	SD	LT
4	LEATHER AND LEATHER PRODUCTS AND FOOTWEAR	19	SD	LT
5	WOOD AND PRODUCTS OF WOOD AND CORK	20	SD	LT
6	PULP, PAPER AND PAPER PRODUCTS	21	SI	LT
7	PRINTING AND PUBLISHING	22	SI	LT
8	COKE, REFINED PETROLEUM PRODUCTS AND NUCLEAR FUEL	23	SI	LT
9	CHEMICALS AND CHEMICAL PRODUCTS	24	SB	HT
10	RUBBER AND PLASTICS PRODUCTS	25	SI	LT
11	OTHER NON-METALLIC MINERAL PRODUCTS	26	SI	LT
12	BASIC METALS	27	SI	LT
13	FABRICATED METAL PRODUCTS (EXCEPT MACHINERY AND EQUIPMENT)	28	SD	LT
14	MACHINERY AND EQUIPMENT, N.E.C.	29	SS	HT
15	OFFICE, ACCOUNTING AND COMPUTING MACHINERY	30	SB	HT
16	ELECTRICAL MACHINERY AND APPARATUS, NEC	31	SS	HT
17	RADIO, TELEVISION AND COMMUNICATION EQUIPMENT	32	SB	HT
18	MEDICAL, PRECISION AND OPTICAL INSTRUMENTS	33	SB	HT
19	MOTOR VEHICLES, TRAILERS AND SEMI-TRAILERS	34	SI	LT
20	OTHER TRANSPORT EQUIPMENT	35	SS	HT
21	MANUFACTURING NC AND RECYCLING	36-37	SD	LT

Service sectors			
SALE, MAINTENANCE AND REPAIR OF MOTOR VEHICLES; RETAIL SALE OF FUEL	50	SD	LT
WHOLESALE, TRADE & COMMISSION EXCL. MOTOR VEHICLES	51	SD	LT
RETAIL TRADE EXCL. MOTOR VEHICLES; REPAIR OF HOUSEHOLD GOODS	52	SD	LT
HOTELS AND RESTAURANTS	55	SD	LT
LAND TRANSPORT	60	SD	LT
SEA TRANSPORT	61	SD	LT
AIR TRANSPORT	62	SD	LT
SUPPORTING AND AUXILIARY TRANSPORT ACTIVITIES	63	SD	LT
POST AND TELECOMMUNICATIONS	64	SB	HT
FINANCIAL INTERMEDIATION (EXCEPT INSURANCE AND PENSION FUNDING)	65	SI	LT
INSURANCE AND PENSION FUNDING (EXCEPT COMPULSORY SOCIAL SECURITY)	66	SI	LT
ACTIVITIES RELATED TO FINANCIAL INTERMEDIATION	67	SI	LT
REAL ESTATE ACTIVITIES	70	SS	HT
RENTING OF MACHINERY AND EQUIPMENT	71	SS	HT
COMPUTER AND RELATED ACTIVITIES	72	SB	HT
RESEARCH AND DEVELOPMENT	73	SB	HT
OTHER BUSINESS ACTIVITIES	74	SS	HT