International Outsourcing, R & D and the Evolution of Wages: the Case of Italian Industry

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Abstract

The aim of this paper is to empirically evaluate the impact of international outsourcing of materials and services and of R&D expenditures on wages of skilled and unskilled workers in Italian industry during the period 1985 − 1997, merging an administrative data set on workers' wages with data on imported inputs from Italian input-output tables and from OECD data on R&D .Our results suggest that R&D intensity has a (negligible) positive impact on real wages, while the fragmentation of production is responsible for increasing wage disparities, because it lowers the wages of Blue Collars, leaving unchanged or raising the remunerations of White Collars.

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1 Introduction

The recent trend in production is characterized by firms fragmenting their production process across several countries in order to save on intermediate costs. This can occur both by means of Foreign Direct Investment (FDI) or a simple subcontracting activity. However, if outsourcing occurs, the gain from factor costs saving is higher than the cost of disintegrating production across different countries[2]. From the end of the 90s, with developing and transition countries becoming more and more active players in global trade and production arenas, the economic literature started addressing this topic with great interest in order to understand the phenomenon and its consequences. For this reason, then, the aim of this paper is to study the relation between international outsourcing and individual wages in Italy during the period 1985 and 1997, in order to understand what consequences substitution of home made inputs with foreign productions can bear for the Italian labor market.

Traditional trade theory based on the Heckscher-Ohlin paradigm predicts unskilled labor abundant countries to export unskilled labor intensive goods and skilled labor abundant countries to export skilled labor intensive goods. This pattern of trade and production would cause relative wages to grow for unskilled labor in labor abundant countries: factor price equalization follows and international and within country inequality is reduced.

Feenstra and Hanson (2001) [13] provide an empirical model contrasting with the traditional Heckscher-Ohlin view of international trade and factor content of exported goods. Starting form the evidence on the U.S. rising inequality between skilled and unskilled labor they show how the phenomenon can actually be related to trade, differently from what is in general considered as a byproduct of technological change. Global sharing of production can produce a shift in labor demand for skilled workers, being labor demand for unskilled workers displaced abroad where this factor's price is cheaper.

[2] Duràn-Lima e Ventura-Dias (2001) [10] clearly explain the different ways in which production can be split between the matrix and the affiliates.
The original way was to reproduce abroad a company which was the copy in small size of the matrix company, with the affiliates producing for the internal market(market seeking, horizontal FDI) with inputs coming mainly from local market and some compulsory linkages with the matrix.
The outsourcing process, instead, would reproduce the typical vertical FDI where, in presence of very low trade costs, the matrix develops parts of the production process abroad in order to exploit costs advantages present in other countries.
Finally, in the International System of Production (ISP), not only parts of a vertical process, but a whole group of functions can be developed abroad thus coming to a kind of FDI which is something in between the other two.

This causes increasing inequality at home and a decreasing share of labor employed in unskilled productions.

Their theoretical model with heterogeneous activities within an industry shows that trade in inputs has the same labor demand shift effect of skill-biased technological change. The authors highlight three different empirical methodologies, according to three different data aggregation levels, to estimate the effects of outsourcing and technological change on wages. Hijzen, Holger and Hine (2004) [16] apply and extend the approach of estimating relative demand functions for skilled workers based on a translog cost function. They use a narrow measure of outsourcing which only considers imported intermediates in a given industry from the same industry over the same industry value added . The Authors estimate a system of four variable factor demands (skilled, semi-skilled, unskilled labor and materials and assume capital to be quasi-fixed) using panel data techniques. They measure outsourcing by means of data from input-output tables and define skill groups more accurately than the rough distinction between manual and non-manual workers. Furthermore, Hijzen et al. control for skill biased technological change. Their results show that outsourcing has had a negative impact on the demand for unskilled labor in the U.K..

Strauss-Kahn (2003) [22], within a similar empirical framework, finds that international vertical specialization contributed from 11 to 15% of the decline in the share of unskilled workers in French manufacturing employment during the period 1977-1985 and for 25% of the decline in the 1985-1993 period. She uses both wide and narrow measures of outsourcing, with the wide measure of outsourcing including imported intermediates from all industries, thus considering also interindustry reallocations. This would measure the effect of the economy wide imported input penetration on labor demand, thus interindustry reallocations would be considered together with within industry ones.

Geishecker and Gorg (2003) [15], instead, investigate the link between outsourcing and wages using a large household panel and combining it with industry level data. They point out that industry level studies are actually affected by endogeneity bias: they claim that international outsourcing is not exogenous to the industry, instead it is an industry's choice variable, and relative labor demand and the extent of fragmentation are then determined simultaneously. Since the industry's fragmentation activities can be considered exogenous to the individual, endogeneity bias due to simultaneous determination of labor demand and international fragmentation of production undertaken at industry level can be overcome using individual wages.

Furthermore they suggest that the evidence of constant skilled-unskilled relative wages in Germany, might actually hide important differentiated impacts of fragmentation of production on individual wages. For this reason they estimate a wage equation controlling for demographic, working and educational characteristics adding some controls for industry and outsourcing. Their results actually show that, despite the evidence of a constant relative wage between skilled and unskilled at aggregate level in Germany, outsourcing has negatively affected low skilled workers' real wage, on the other hand produced some gains for skilled workers.

Geishecker (2005) [14] finds that outsourcing significantly lowers individual employment security in Germany manufacturing industries between 1991 and 2001, though the effect does not significantly differ between high, medium and low skilled workers. The risk of job loss is captured within a hazard rate model controlling for the duration dependence of job separations.

Finally, Helg and Tajoli (2005) [21] analyze the relation between the pattern of international fragmentation of production and the relative demand for labor in Europe, specifically focusing on Italy and Germany. They test if fragmentation undertaken especially in industries traditionally considered intensive in unskilled labor, favors skilled labor. They measure international outsourcing as outward processing trade and use an International Fragmentation of Production (IFP) index calculated as the ratio of re-imports of industry j over domestic production of industry j. The estimation of the equation measuring labor demand shows that the index of international fragmentation is consistently positive and significant for Italy, implying that part of the increase in the skilled-to-unskilled labor ratio in Italy is due to this phenomenon. For Germany, on the other hand, IFP appears not to influence the relative demand for skilled labor[3]. Despite outward processing trade actually identifies a big part of outsourcing, the authors suggest that the use, in their paper, of a strictly defined measure of fragmentation such as outward processing trade might actually underestimate the more general phenomenon of outsourcing.

Despite the above evidence of trade causing increasing inequality between skilled and unskilled workers, part of the economic literature has found in the

[3]The authors point out that the net effect of IFP on the labor market depends upon which phases of production are relocated, in which industries and toward which countries relocation takes place, and on how this affects the overall composition of output: the effect should be stronger when the fragmenting sector is larger and more distant from the country's average in terms of factor usage. In Italy, the weight of traditional sectors resorting to IFP is high and they are characterized by low skilled-unskilled ratios. Therefore, one would expect IFP to play a role there. Their results, then, show that such an impact exists, even if small. The same though does not occur in Germany where the industries which are mostly affected by IFP have skilled-unskilled ratios much closer to the national manufacturing average, so that IFP in those industries on average does not have a strong impact on labor demand.

skill-biased technological change an alternative, or at least complementary, explanation for this phenomenon. Acemoglu (2002) [1] surveys some stylized facts on technological change and the pattern of wages for the U.S. economy and thoroughly reviews the debate on the topic under a unifying theoretical framework.

The behavior of technological change can be understood recognizing that the development of new technologies is, in part, a response to profit incentives: the greater availability of skilled workers in the twentieth century has made more profitable to develop skill-biased technological change (SBTC), while, previously, the great availability of unskilled labor made more profitable the development of skill-replacing technological change[4]. Hence, recent technological developments affected the organization of firms, of labor markets and of labor markets institutions, resulting in large effects on wages.

Despite the relevance of technological change in partially determining wage patterns, the recent literature focuses on the complementarity between new technologies and organizational changes in leading to a higher demand for skilled workers: new technologies potentially provide productivity gains, but their effective implementation takes time and becomes productive only if the workforce is properly educated and trained. Bresnahan et al. (2002) [6] study a panel of around 300 large US firms over the 1987-94 period (industry and services), with detailed data on Information Technology (IT) capital, skills (by education and position) and a list of organizational practices (team-based work, self-managing teams, distribution of decision authority, etc.). They confirm a significant relation of complementarity between new technologies, organizational change and human capital. Caroli and Van Reenen (2001) [8], instead, find that, in the wage bill share equation, the (lagged) dummy for organizational change significantly explains the skill bias, particularly in terms of a reduction of the demand for the unskilled workers, both in a sample of French (in 1992-1996) and British firms (in 1984-90).

Bratti and Matteucci (2005) [5] nicely survey the empirical literature on SBTC in Europe and they underline that the evidence in favor of SBTC is less straightforward for European countries as a whole than for US. In particular, concerning Italy, initial evidence in favor of SBTC has not been confirmed in recent contributions. They perform an empirical analysis of the effect of some proxies for firms' technological capital, such as R&D and ICT expenditures on the skill-ratio using Italian manufacturing data. When considering R&D expenditures by destination they find a negative effect on

[4]Machin and Van Reenen (1998) [17] confirm the SBTC hypothesis studying a panel of 7 countries (Denmark, France, Germany, Japan, Sweden, UK, US) over various time intervals (within the period 1973-89) with 15 manufacturing sectors.

the skill-ratio of R&D devoted to improving old processes and a positive effect of R&D expenditures borne to introduce new processes. As far as ICT is concerned, they do not generally find significant effects, either positive or negative, on the skill-ratio. This evidence could merely reflect a delay in the adjustment path.

Within this theoretical and empirical framework, the present paper intends to detect the effect of international outsourcing and innovation on Italian workers' wages in the manufacturing sectors, making use of a large panel data set on workers and measuring outsourcing as total materials outsourcing and business and financial services outsourcing. We expect material outsourcing to negatively affect relative wages for blue collar while we expect business and financial services outsourcing to negatively affect white collars' relative wages.

The paper is organized as follows: Section 2 presents the data sets and the variables; Section 3 discusses the empirical model and the different estimation techniques; Section 4 presents and discuss the results, and Section 5 concludes.

2 Data and Variables

To analyze the impact of outsourcing and innovation on wage evolution, we build a database for more than 120,000 workers observed from 1985 and 1997, merging three different data sets which contain information on individual wages and characteristics, on R&D expenditures and on outsourcing.

The Italian Institute for National Social Security (INPS thereafter) collects data on all Italian workers employed in the private sector (except agriculture) through an administrative procedure based on firms' declarations. Because of the administrative nature of the data, only few individual variables are collected on workers. In particular, yearly gross wages[5], weeks and days of work, gender, age, qualification, region of the workplace, firms' sector and size are available but, unfortunately, educational levels, family composition and family background are missing. Data are available from 1985 to 1999.

In the paper, we employ a sample of the whole data set, rearranged by ISFOL[6], which collects information on every workers born the 10th of March, June, September and December of each year. Thus, 1 worker out

[5] Gross wages are the sum of net wages, taxes and social contributions on workers; social contributions on firms are not included in gross wages.

[6] *Istituto per lo Sviluppo della Formazione Professionale dei Lavoratori* (Institute for Training Workers)

of about 91 is included in the sample and the whole data set is composed by more than 2100000 observations[7]. We calculate the daily individual real wages ($WAGE$) dividing the yearly gross nominal wages by the number of working days and by the CPI index[8]. Besides, daily wages, firm's sector and size of workers with more than one job during the some year (10.67% of all observations) have been chosen considering the job lasted the most and, in the case of same length (0.30% of all observations), the job with the highest wage. We dropped outlier observations in wages (daily gross real wage higher than 5 million and lower than 1650 Italian (1985) lire) and workers who did not work during the whole year. Given that outsourcing measures are available only until 1997, we drop observations for years 1998 and 1999 and observations referring to individuals working in the service sectors in order to focus the analysis on the industrial sector only.

Expenditure on R&D comes from the OECD "Research and Development Expenditure in Industry database, 1973-1998" and the measure of R&D intensity (RD) is calculated as a share of the total value added, at industry level[9]. Given the different definition of sectors, we grouped some of our sectors: Vegetables, Milk and Dairy Products; Fabrication of Other Alimentary Products; Fabrication of Drink and Beverage; Tobacco are all collected in the sector: "Food, Beverages & Tobacco" of the OECD classification. Therefore, shares of R&D in the above sectors are the same. We also made some relevant assumptions concerning the sector of Machinery and Equipment n.e.c.[10].

The measures of outsourcing are drawn from the data contained in the Italian input-output tables, elaborated by Giorgio Rampa[11]. The outsourcing phenomenon is measured via three different indicators, available at industry level. Firstly, two broad measures of materials and services outsourcing are used: $OUTM$ and $OUTS$ indicates, respectively, the overall imported inputs from manufacturing sectors abroad, and the total business and financial services purchased from abroad, over total intermediate inputs costs. Secondly, according to the previous literature on the topic (see Feenstra and Hanson, 1999 [12]), we employ a measure of narrow outsourcing ($OUTN$), defined as the cost for intermediate inputs that sector j imports from sector j abroad over total intermediate costs. In other words, this is a within industry mea-

[7]For a detailed description of the dataset, see Centra and Rustichelli (2005)[9]

[8]This price index is calculated by the Italian Institute of Statistics (ISTAT) with respect to blue and white collars households.

[9]Data on Value Added are drawn from the OECD Stan Database. Both data sets are available on www.sourceoecd.org, last accessed September 2006.

[10]The "industrial and agricultural machinery" sector's share is calculated on the whole sector "fabricated metal products"

[11]The data set is available at *http ://www.giuri.unige.it/iotables/index.html*.

Table 1: Workers presences in the data set, by year and skill

year	Blue Collar	White Collar	Total
1985	35337	8644	43981
1986	40040	11134	51174
1987	40267	11416	51683
1988	40818	11869	52687
1989	40766	12317	53083
1990	38933	12053	50986
1991	39959	12854	52813
1992	38294	12716	51010
1993	38617	13413	52030
1994	38579	13148	51727
1995	39379	13063	52442
1996	39693	13314	53007
1997	38603	13418	52021
Total	509285	159359	668644

Source: panel ISFOL on INPS data.

sure representing how much of the cost for intermediates produced within the same national industry is shifted to intermediate purchases from the same industry abroad.

Table 1 shows the number of observations in our (unbalanced) panel, by skills and years. They refer to 123647 workers, 11385 of them are observed for each year, while the median of the presences in the data set is four years and the average is 5.4 years.

The analysis of the temporal evolution of our key variables shows that real wages grew steadily until 1994, when the "Protocollo sulla politica dei redditi e dell'occupazione" (signed in 1993 by the government and social partners), that introduced in bargaining the method of "concertazione" and the two-tier bargaining system, both at sectoral and firms level, probably played a role in the real wages reduction occurred in 1995 and 1996. The R&D intensity, instead, increased during the 1980s and it remained almost stable thereafter. With respect to outsourcing, the wide measure of materials ($OUTM$) steadily increases in the period under analysis, partially reflecting the trend emerging for the narrow measure of outsourcing in the last column of Table 2, while the share of imported business and financial services inputs over total intermediate costs nearly doubled during the sample period (+77%), even if it is still much smaller than the other indicators.

Table 2: Daily Real Wages, R&D Intensity, and Outsourcing indicators, yearly averages

year	WAGE	RD	OUTM	OUTS	OUTN
1985	30.63	0.025	0.135	0.013	0.096
1986	31.45	0.029	0.140	0.014	0.106
1987	31.95	0.031	0.140	0.014	0.106
1988	32.14	0.032	0.139	0.012	0.105
1989	32.92	0.032	0.142	0.012	0.106
1990	33.22	0.035	0.141	0.017	0.105
1991	34.60	0.037	0.145	0.016	0.108
1992	35.95	0.038	0.148	0.023	0.111
1993	35.77	0.037	0.166	0.024	0.126
1994	37.42	0.035	0.186	0.022	0.145
1995	33.26	0.034	0.212	0.020	0.170
1996	32.97	0.034	0.197	0.021	0.155
1997	34.01	0.036	0.217	0.023	0.173
Total	33.60	0.034	0.162	0.018	0.125

Source: panel ISFOL on INPS data; Giorgio Rampa dataset; OECD STAN database.

The disaggregation by sectors reported in Table 3 points out that the highest shares of the narrow and wide measures of outsourcing emerge for the traditional sectors (e.g. Leather, Textiles and Clothing) and for the more advanced too. Especially, the Electronics and the Electrical Appliances industries report the highest shares of materials outsourcing, with services outsourcing being particularly important for these sectors (as well as for Agricultural and Machinery sectors). Among the subset of the traditional industries, the Leather sector displays the highest share of material outsourcing, despite the within industry substitution measured with $OUTN$ is nearly half of the overall process of substitutions of national material imports with imported ones, measured by $OUTM$. The Textiles and Wood sectors follow with lower, but still important, shares of materials outsourcing, almost entirely reflecting the within sector substitution process. The outsourcing of services, eventually, seems to be more relevant for more advanced sectors and this is quite reasonable if one thinks that business and financial services especially involve R&D. As regards innovation, in fact, we can observe that it is basically concentrated in three sectors (Electrical Appliances, Car Production and Ship Building and Railways), with share of R&D expenditure close to 20%.

This preliminary evidence, might actually confirm what discussed by Helg and Tajoli (2005) [21] about the Italian outsourcing process being characterized by technology dependence for more advanced sectors and by cost saving reasons for traditional sectors.

Table 3: Daily Real Wages, R&D Intensity, and Outsourcing indicators, by industry

Industries (Ateco Code)	At81	WAGE	RD	OUTM	OUTS	OUTN
Metals	13	55.87	0.013	0.010	0.018	0.279
Non Metallic Products	15	33.30	0.002	0.023	0.009	0.059
Chemical Products and Synthetic Fibres	17	44.20	0.063	0.266	0.012	0.257
Metallurgy	19	31.36	0.024	0.028	0.027	0.015
Agricultural and Industrial machines*	21	36.07	0.063	0.188	0.029	0.142
Electronics	23	41.23	0.032	0.386	0.022	0.284
Electrical Appliances	25	34.11	0.199	0.253	0.023	0.221
Car Production and Components	27	37.64	0.127	0.192	0.013	0.096
Ship Building, Railways and Motorcycle	29	37.77	0.174	0.211	0.024	0.130
Production and Transf. of Meat and Fish**	31	32.12	0.003	0.057	0.009	0.055
Milk and Dairy Products**	33	35.99	0.003	0.166	0.006	0.164
Other Alimentary Products**	35	33.19	0.003	0.052	0.006	0.039
Drinks and Beverages**	37	38.99	0.003	0.052	0.013	0.014
Tobacco**	39	25.94	0.003	0.009	0.026	0.000
Textiles and Clothing***	41	26.73	0.000	0.197	0.015	0.143
Leather***	43	25.92	0.000	0.306	0.015	0.172
Wood and Furniture	45	26.28	0.001	0.142	0.006	0.124
Paper, Publishing and Press	47	36.72	0.001	0.188	0.010	0.167
Rubber and Plastic Products	49	32.84	0.015	0.333	0.012	0.088
Other General Manufacturing	51	34.79	0.001	0.039	0.045	0.009
Total		33.60	0.034	0.162	0.018	0.125

* The share of R&D is computed on "Machinery and Equipmnet n.e.c" (OECD)
** The share of R&D is computed on "Food, Beverage and Tobacco" (OECD)
*** The share of R&D is computed on "Textiles, Apparel Leather " (OECD)
Source: panel ISFOL on INPS data; Giorgio Rampa dataset; OECD STAN database.

The distribution of $WAGE$, RD, $OUTM$, $OUTS$ and $OUTN$ across Italian regions (Tables 4) appears to be more uniform, despite the highest shares of outsourcing are observed for the central and northern regions, especially where cluster of manufacturing activities, the "distretti", are present (e.g, Veneto, Marche and Toscana. The highest share of Marche might be joined with what observed for the leather sector as a pattern of dismantling of the shoe cluster).

Finally, as for firm size, it is straightforward the positive relation depicted by Tables 5 between dimension and wide (and narrow) materials outsourcing, R&D intensity and wages, while the same does not occur for outsourcing of services, which is generally more stable.

Table 4: Daily Real Wages, R&D Intensity, and Outsourcing indicators, by regions

Regions	WAGE	RD	OUTM	OUTS	OUTN
Piemonte	35.43	0.051	0.168	0.018	0.118
Valle D Aosta	35.97	0.020	0.101	0.019	0.154
Lombardia	35.41	0.036	0.173	0.019	0.136
Trentino Alto Ad	31.39	0.025	0.141	0.016	0.114
Veneto	29.67	0.025	0.160	0.017	0.121
Friuli Venezia G	31.62	0.040	0.148	0.017	0.122
Liguria	47.63	0.049	0.150	0.019	0.131
Emilia Romagna	32.59	0.033	0.145	0.018	0.109
Toscana	30.56	0.023	0.173	0.017	0.129
Umbria	29.72	0.019	0.136	0.016	0.119
Marche	27.36	0.026	0.197	0.017	0.133
Lazio	41.50	0.032	0.172	0.019	0.143
Abruzzo	29.11	0.026	0.163	0.016	0.122
Molise	31.55	0.033	0.142	0.015	0.105
Campania	36.50	0.039	0.157	0.017	0.116
Puglia	30.89	0.022	0.151	0.016	0.123
Basilicata	31.61	0.039	0.150	0.016	0.114
Calabria	28.81	0.016	0.114	0.015	0.094
Sicilia	28.46	0.027	0.110	0.020	0.085
Sardegna	31.57	0.028	0.117	0.016	0.109
Total	33.60	0.034	0.162	0.018	0.125

Source: panel ISFOL on INPS data; Giorgio Rampa dataset; OECD STAN database.

Table 5: Daily Real Wages, R&D Intensity, and Outsourcing indicators, by size

size	WAGE	RD	OUTM	OUTS	OUTN
less than 20	26.13	0.022	0.147	0.018	0.108
between 20 and 49	31.45	0.023	0.157	0.018	0.115
between 50 and 99	34.15	0.028	0.159	0.019	0.120
between 100 and 199	36.67	0.031	0.162	0.018	0.125
between 200 and 499	38.52	0.038	0.170	0.018	0.137
more than 499	44.50	0.065	0.192	0.017	0.157
Total	33.59	0.034	0.162	0.018	0.125

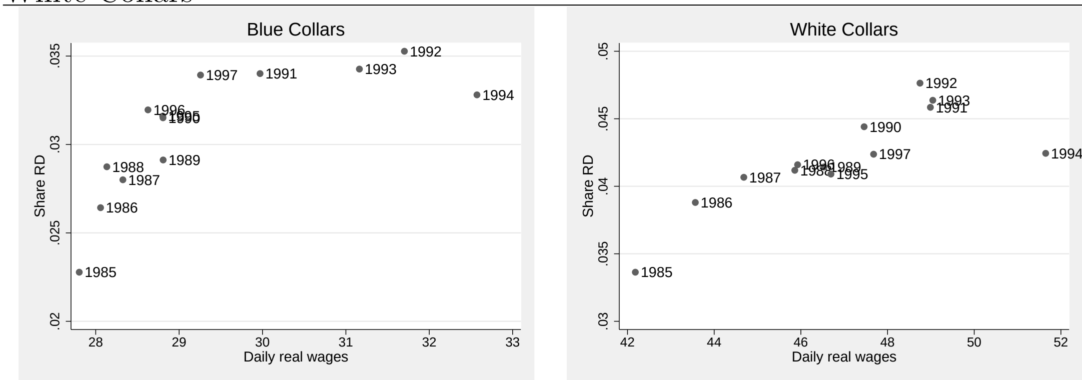
Source: panel ISFOL on INPS data; Giorgio Rampa dataset; OECD STAN database.

Given that one of the aim of the paper is to analyze the effects of outsourcing and R&D intensity on wage inequality, we plot the relationship between RD, $OUTM$, $OUTS$ and $OUTN$ on Blue and White collar wages during the period 1985-1997 (Tables 6, 7, and 8).

Table 6 points out a positive correlation between innovation and wages, while the visual analysis of the relationship between outsourcing and remunerations is less clear.

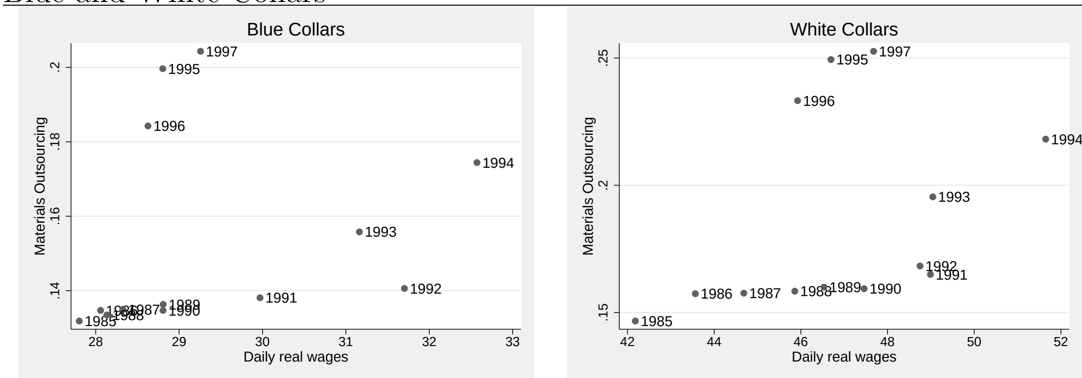
The fragmentation of industrial production seems to be associated with rising compensations until 1994, while the further increase in the share of outsourced production was related with a significant decline in real wages, both for Blue and White collars (tables 7-9). Eventually, a similar pattern occurred also for $OUTS$ in the case of unskilled workers, whilst the decline in skilled workers' remunerations in the period 1994-96 was much less noticeable. "Narrow" outsourcing, finally, increased strongly in the $'90th$, following a pattern similar to materials outsourcing, suggesting that the share of intra- and inter-industry outsourcing increased almost proportionally.

Table 6: Relationship Between R&D Share and Daily Real Wages, Blue and White Collars



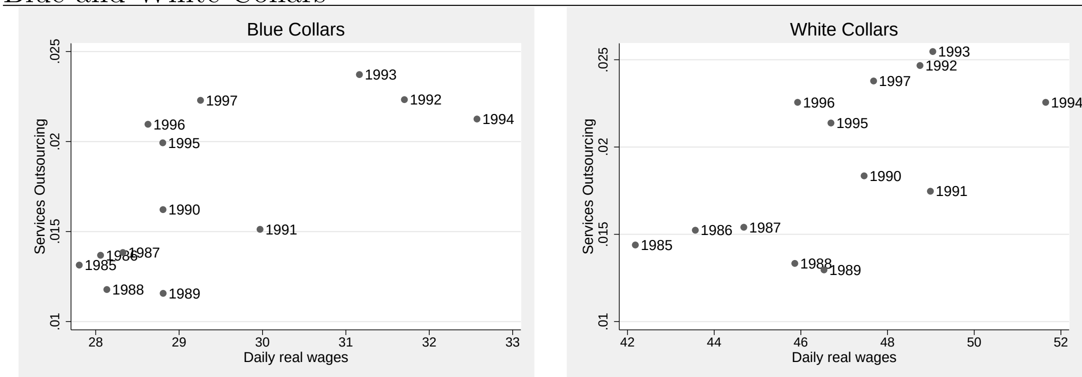
Source: panel ISFOL on INPS data; OECD Stan database.

Table 7: Relationship Between Materials Outsourcing and Daily Real Wages, Blue and White Collars



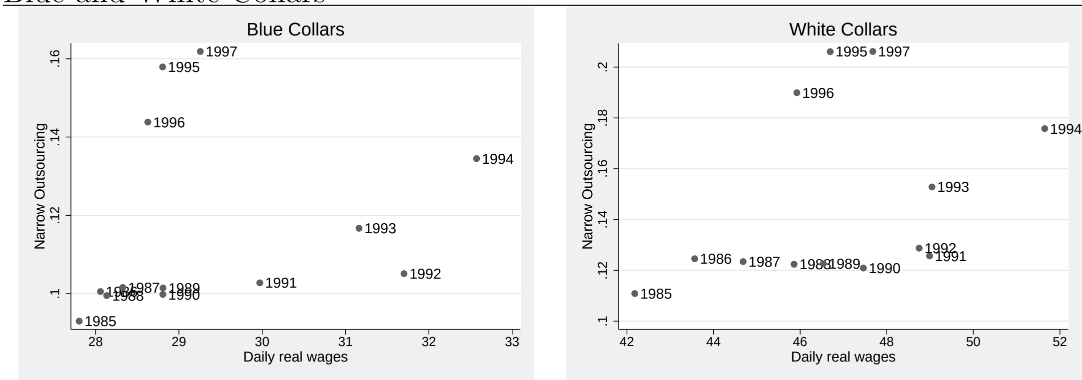
Source: panel ISFOL on INPS data; Giorgio Rampa dataset.

Table 8: Relationship Between Services Outsourcing and Daily Real Wages, Blue and White Collars



Source: panel ISFOL on INPS data; Giorgio Rampa dataset.

Table 9: Relationship Between "Narrow" Outsourcing and Daily Real Wages, Blue and White Collars



Source: panel ISFOL on INPS data; Giorgio Rampa dataset.

3 The Empirical Model

The empirical model is a standard wage equation (see, among others, the seminal contributions of Mincer (1974) [18] and Brown (1989) [7]), in which we add two measures of materials and services outsourcing and a variable related to R&D intensity. Thus, the wage equation for the panel data set is given by:

$$\begin{aligned} ln(WAGE_{i,j,t}) = \alpha_0 + \beta_0 IND_{i,t} + \beta_1 WORK_{i,t} + \quad + \\ \theta_0 RD_{j,t} + \delta_0 OUT_{j,t} + \tau_{j,t} + \mu_t + \iota_i + \epsilon_{i,t} \end{aligned} \tag{1}$$

where, $WAGE_{i,j,t}$ is the daily real wage of individual i employed in the industry j at time t, $IND_{i,t}$ and $WORK_{i,t}$ are a set of variables measuring individual demographic characteristics and work features. In particular, IND includes individual specific data: age, number of weeks worked per year and tenure, together with their squared values, to take into account for nonlinearities and worker status, which is classified into two broad categories: blue and white collars[12]. $WORK$ refers to variables related to the workplace of individual i and includes firm's size (a six categories variable, see Table5) and the region where the firm is located. With respects to our key variables, $RD_{j,t}$ is the measures of R&D intensity of industry j at time t while $OUT_{j,t}$ indicates the degree of outsourcing of industry j at time t. Depending on the model specification, we will include business and financial services outsourcing ($OUTS_{j,t}$)) and one of the two variables of materials ousourcing:

[12]This variable could be thought as a proxy for the level of education achieved by the individual i.

the wide, $OUTM_{j,t}$, or the narrow measure $OUTN_{j,t}$[13]. Eventually, $\tau_{j,t}$ represents industry specific time effects (20 sectors, according to the ateco 81 classification, 2 digits), ι_i are time invariant individual effect, μ_t are time specific effects, and $\epsilon_{i,t}$ is an idiosyncratic shock affecting individual wage at time t.

Equation 1 could be estimated with standard Fixed (FE) or Random Effects (RE) and first differencing (FD) methods. However, since these estimators are based on the assumption of homoskedasticity and no serial correlation of the idiosyncratic error, it is critical to deal with both heteroskedasticity and autocorrelation of $\epsilon_{i,t}$, which are likely to affect our model, leading to inconsistent standard error. As regards the latter point, we could test for the presence of serial correlation following a solution proposed by Wooldridge (2002) [23] and implemented in Stata by Drukker (2003) [11], based on the AR(1) serial correlation of the residuals obtained from the first differenced model:

$$\begin{aligned}\Delta ln(WAGE_{i,j,t}) = \alpha_0 + \beta_0 \Delta IND_{i,t} + \beta_1 \Delta WORK_{i,t} \quad + \\ + \theta_0 \Delta RD_{j,t} + \delta_0 \Delta OUT_{j,t} + \Delta\tau_{j,t} + \Delta\mu_t + \Delta\epsilon_{i,t}\end{aligned} \tag{2}$$

The test is based on the fact that under the null hypothesis of homoskedasticity and no autocorrelation of $\epsilon_{i,t}$, the correlation between $\upsilon_{i,t}$ and $\upsilon_{i,t-1}$ will be equal to -0.5 (where $\upsilon_{i,t} = \Delta\epsilon_{i,t}$). Thus, it is possible to run the following OLS regression:

$$\widehat{\upsilon}_{i,t} = \rho\widehat{\upsilon}_{i,t-1} + \zeta_{i,t}$$

and test for $\rho = 0.5$[14]. Therefore, since the test rejects the null hypothesis, we will estimate equation 1 using the variance-covariance matrix corrected both for heteroskedasticity and serial correlation. Eventually, with respect to the choice between the FE and the RE estimators, we perform two different versions of the Hausman test (see Wooldridge, pp. 288-290 [23]), rejecting, in both cases, the null hypothesis[15]. Thus, we will present the results obtained using exclusively the Least Square Dummy Variable (LSDV) and the First Difference (FD) estimators.

[13] Given that the couple $OUTM$ and $OUTS$ and the narrow indicator are constructed on the ground of different definitions of outsourcing, they can not be included simultaneously into the regression.

[14] Given the presence of heteroskedasticity we use the robust variance-covariance matrix for the FD estimates.

[15] This results is also consistent with the *a priori* that, in our specification, the additional hypothesis required by the RE of uncorrelation between the unobserved effects (i.e. education, innate ability) and the explanatory variables is likely to fail.

Because the presence of residual autocorrelation, we will also specify a dynamic equation, in which we add two lags of the dependent variable, in order to get the persistence in wage formation, as well as the lagged values of RD, $OUTM$ and $OUTS$ in $t-1$ and $t-2$[16]. Thus, equation 1 becomes:

$$
\begin{aligned}
ln(WAGE_{i,j,t}) = \alpha_0 + \sum_{n=1}^{2} \gamma_n ln(WAGE_{i,j,t-n}) + \beta_0 IND_{i,t} + \beta_1 WORK_{i,t} + \\
+ \sum_{n=0}^{2} \theta_n RD_{j,t-n} + \sum_{n=0}^{2} \delta_n OUT_{j,t-n} + \tau_{j,t} + \mu_t + \iota_i + \epsilon_{i,t} \quad (3)
\end{aligned}
$$

Time-demeaning and first-differencing transformation does not provide consistent estimate, because of the correlation between the lagged wage and the error term. In particular, the Within Group estimator is biased downwards (Nickell, 1981 [20]) and the degree of correlation is of order $1/T$, so that the LSDV becomes a consistent estimator, if the time span of the panel is long enough (Nerlove, 1999 [19]). On the other hand, the OLS estimation of the first-differencing transformation of equation 3 gives inconsistent and downward biased estimate, but, if Two Stages Least Squares(2SLS) with Instrumental Variable are applied to the first-differenced equation, consistent estimates are obtained for a fixed $T(T > 3)$ and a large N (Bond, 2002 [4]). This is the solution proposed by Anderson and Hsiao (1981) [2], who suggest the use of the log of the wage level in $t-2$ as instrument for $\Delta ln(WAGE_{i,j,t-1})$, given that $ln(WAGE_{t-2})$ is both correlated with $\Delta ln(WAGE_{i,j,t-1})$ and orthogonal to $\Delta\epsilon_{i,t}$. Besides, econometric literature suggests the use of the Generalized Method of Moments (GMM) to estimate dynamic panel data models. Specifically, efficient and consistent (asymptotically) estimates are given by the Difference-GMM (Arellano and Bond, 1991 [3]), which basically extends the previous idea considering all the feasible lagged values of the predetermined variables as valid instruments for the endogenous variables.

For our purposes, and to check for the robustness of results across different estimators, we presents the estimates obtained using the LSDV and the FD

[16] The choice of the lag of the dependant variable is made because of the high degree of persistence of wages: the inclusion of one lag, in fact, is not enough to address the serial correlation issue, as confirmed by the autocorrelation tests performed on the residual of the 2SLS estimates. As regards the lags of the key variables, we have tried different specifications, with one to six lags. Preliminary results suggested that adding more lags does not improve the informative power of the regression analysis, whilst it greatly reduces the sample size. Furthermore, in Italy industry level collective agreements among social partners take place every two years, setting wages for the following two years period, so that the effect of outsourcing could be transferred on wages with some lapse.

estimators, corrected for the presence of intra-group serial autocorrelation and heteroskedasticity, and the 2SLS estimates with robust standard errors. Since our panel has a very wide span and it covers 13 years, we expect that results will not differ too much, even if we are more confident on the Anderson-Hsiao estimates which are consistent even with small T[17].

Eventually, since we are interested in ascertain whether investment intensity in R&D and the degree of outsourcing affect real wages differently according to worker' skills, we estimate equations 1 and 3 including the contemporaneous and lagged (only for the dynamic model) values of the interactions between the dummy for white collars with $RD_{j,t}$, and the included outsourcing indicators ($OUTS_{j,t}$ and $OUTM_{j,t}$ or $OUTN_{j,t}$, depending on model's specification).

4 Results

The results of the estimation of equations 1 and 3 using the materials and services outsourcing indicators are reported in the Table 10, which refers to the static model, and in Tables 11 - 13, that show the results of the dynamic specification. To have a better approximation of the quantitative effects of fragmentation and innovation of wages, we present and discuss the short (when possible) and long run elasticities, reckoned from the coefficients which, instead, can be interpreted as semi-elasticities. We find that the sign and significance or the coefficients on RD, $OUTM$ and $OUTS$ are generally stable across the different estimators, with some exceptions for the FE results[18], whilst elasticities computed using the FD and the 2SLS are roughly similar. Thus, because the Anderson-Hsiao estimates are consistent and pass the autocorrelation tests, we will discuss our findings referring to 2SLS results. Finally, we do not show the coefficients on the control variables included in IND and $WORK$, which are always significant and with the expected signs[19], dummy variables for industries, firm size, regions and

[17]Difference-GMM estimates will be performed in future drafts of the paper.

[18]In particular, with respect to services outsourcing in equation 1 and on R&D share in equation 11.

[19]Complete Tables are available on request from the authors. Referring in particular to the $2SLS$ equation on the whole sample (but the following results holds for the other specifications) the daily real wage is affected by:

- age, by a concave relationship, with a maximum for workers aged around 40 years.
- the number of worked week, by a convex relationship with a minimum for about 40 week worked
- tenure, with a increasing convex relationship

years.

Besides, elasticities are generally similar when estimated with the static or the dynamic wage equation, suggesting that both models should be well specified, even if equation 3 is more informative.

The steady-state relation estimated by equation 1 points out that, for the overall sample, the average effect on workers compensations is positive for R&D expenditures and negative in the case materials outsourcing, while the impact of the business and financial services outsourcing changes according to the estimators used. When allowing for the possibility of different slopes according to different working status (columns 3 and 4 of Table 10) results become more insightful: the degree of fragmentation, in fact, has an adverse effect on Blue Collar wages and a positive one on skilled workers, regardless of the kind of the productive process which is moved abroad outside the sector. Eventually, the elasticities of R&D intensity are positive both for Blue and White collars, with a larger effect on the former, according to the within group estimates[20].

Moving to the dynamic specification, the results on the overall sample confirm the previous findings, with a positive long-run elasticity of innovation and negative long-run effects of the fragmentation of production (the sign on the elasticity of $OUTS$ now is unambiguously negative, even if the FE coefficient is not significant, see Table 11)[21]. While the share of expenditure on Research and Development on total value added does not seem to have a different impact on the remunerations of skilled and unskilled workers, the degree of outsourcing, instead, has different and significant long run impact on wages, according to worker status, as showed by tests on the joint significance of the interaction terms reported at the bottom of Table 12. Both the two measures of fragmentation have negative and highly significant long run elasticities with respect to Blue Collar wages, while the corresponding elasticities for White Collars are positive (and marginally significant) for materials outsourcing and not significantly different from zero (but still positive) for $OUTS$ (Table 13).

As stressed before, the estimation of a dynamic equation has the advantage of allowing for the derivation of both short-run and long-run elasticities. Disentangling these two effects could be very useful in this exercise, since we would expect the outsourcing of part of the production process to have a

[20]The differences in elasticities according to worker status are always significant, apart from services outsourcing when estimated in first differences.

[21]As said, the comparison between FE, FD and 2SLS does not show large differences, even if, the semi-elasticity estimated by the 2SLS are not significant for the lagged terms of RD, $OUTM$, and $OUTS$.

Table 10: Estimation of equation 1

Dependent variable: Real Wage	*FE*	*FD*	*FE*	*FD*
Dummy white collars	0.079	0.040	-0.040	0.039
	(22.01)***	(10.75)***	(6.97)***	(10.55)***
Share R&D	0.220	0.076	0.283	0.078
	(6.27)***	(7.12)***	(7.71)***	(6.45)***
Out materials	-0.082	-0.025	-0.202	-0.041
	(4.65)***	(1.3)	(10.90)***	(1.86)*
Out services	0.358	-0.423	-0.803	-0.697
	(1.98)**	(2.37)**	(4.37)***	(3.74)***
Share R&D x dummy WC			-0.148	-0.008
			(3.67)***	-0.720
Out materials x dummy WC			0.278	0.055
			(16.49)***	(2.23)**
Out services x dummy WC			3.868	0.973
			(21.09)***	(4.91)***
Observations	668644	519910	668644	519910
Number of groups	123647	92686	123647	92686
Elasticities				
	All sample		**Blue collars**	
share RD, LR	0.0074	0.0027	0.0095	0.0027
	(39.37)***	(50.74)***	(59.41)***	(41.61)***
out materials, LR	-0.0133	-0.0043	-0.0327	-0.0068
	(21.66)***	(1.68)	(118.88)***	(3.46)*
out services, LR	0.0064	-0.0077	-0.0143	-0.0126
	(3.93)**	(5.63)**	(19.12)***	(13.98)***
			White collars	
share RD, LR			0.0045	0.0024
			(30.55)***	(24.14)***
out materials, LR			0.0125	0.0025
			(151.84)***	(2.98)*
out services, LR			0.0546	0.0050
			(222.39)***	(14.97)***

* significant at 10%; ** significant at 5%; *** significant at 1%
Robust t statistics in parentheses
For elasticities, F statistics are reported (Chi squared for AH)

Control variables are: age, age squared, week, week squared, tenure, tenure squared, dummies for year, regions, industry, firm size

Source: panel ISFOL on INPS data; Giorgio Rampa dataset; OECD STAN database.

negative immediate impact on salaries, because of a lowered demand labor curve, and a subsequent positive feedback due to eventual gains in productivity. Our findings are not consistent with this pattern when we look at the entire sample, while the picture changes substantially when we allow for heterogeneity across skills. Blue Collars, in fact, are subject to a negative and worsening impact of services and material outsourcing, while White Collars do not experience any significant impact on their wages, which, however, are positively affected or remain unchanged in the long run. R&D intensity, instead, does not show any particular break over time, consistently with the presumption that its positive impact on productivity and, therefore, on remunerations, should be smoother.

Table 11: Estimation of equation 3

Dependent variable: Real Wage	*FE*	*FD*	*2SLS*
Real wage (-1)	0.232	-0.375	0.137
	(34.38)***	(61.83)***	(9.16)***
Real wage (-2)	0.091	-0.131	0.025
	(18.80)***	(30.74)***	(4.74)***
Dummy white collars	0.060	0.048	0.045
	(15.36)***	(11.32)***	(9.08)***
Share R&D	-0.086	0.119	0.062
	(2.56)**	(9.74)***	(4.79)***
Share R&D (-1)	0.017	0.017	0.004
	(2.81)***	(2.80)***	-0.700
Share R&D (-2)	0.010	0.000	-0.005
	(1.88)*	(0.03)	(0.86)
Out materials	-0.083	-0.058	-0.042
	(4.90)***	(2.87)***	(1.83)*
Out materials (-1)	-0.024	-0.033	-0.008
	(1.77)*	(2.66)***	(0.57)
Out materials (-2)	0.016	-0.011	-0.001
	(1.4)	(0.9)	(0.07)
Out services	-0.579	-0.746	-0.765
	(3.39)***	(4.17)***	(3.70)***
Out services (-1)	0.003	-0.305	0.057
	(0.03)	(2.54)**	(0.47)
Out services (-2)	0.452	-0.212	-0.103
	(4.23)***	(2.05)**	-0.920
Observations	416515	335395	335395
Number of groups	75722	63677	63677
AR (1)			0.000
AR (2)			0.570
Elasticities			
share RD, SR	-0.0031	0.0045	0.0023
	(6.54)**	(94.89)***	(22.99)***
out materials, SR	-0.0142	-0.0102	-0.0074
	(24.06)***	(8.22)***	(3.36)*
out services, SR	-0.0107	-0.0141	-0.0144
	(11.51)***	(17.41)***	(13.66)***
share RD, LR	-0.0032	0.0034	0.0027
	(3.17)*	(123.09)***	(25.86)***
out materials, LR	-0.0228	-0.0119	-0.0105
	(31.02)***	(15.37)***	(3.69)*
out services, LR	-0.0034	-0.0158	-0.0182
	(-0.46)	(24.41)***	(9.87)***

* significant at 10%; ** significant at 5%; *** significant at 1%
Robust t statistics in parentheses
For elasticities, F statistics are reported (Chi squared for 2SLS)
AR(i): autocorrelation tests (p values) on the residuals

Control variables are: age, age squared, week, week squared, tenure, tenure squared, dummies for year, regions, industry, firm size

Source: panel ISFOL on INPS data; Giorgio Rampa dataset; OECD STAN database.

Table 12: Estimation of equation 3 with interaction White and Blue collars

Dependent variable: Real Wage	*FE*	*FD*	*2SLS*
Real wage (-1)	0.230	-0.375	0.160
	(33.79)***	(61.86)***	(11.02)***
Real wage (-2)	0.088	-0.132	0.032
	(18.02)***	(30.80)***	(6.13)***
Dummy white collars	-0.019	0.045	0.044
	(3.12)***	(10.75)***	(8.67)***
Share R&D	-0.016	0.111	0.063
	(0.44)	(8.33)***	(4.37)***
Share R&D (-1)	0.015	0.001	-0.009
	(2.10)**	-0.200	(1.24)
Share R&D (-2)	0.000	-0.014	-0.011
	(0.01)	(2.16)**	(1.51)
Out materials	-0.134	-0.084	-0.064
	(7.23)***	(3.71)***	(2.48)**
Out materials (-1)	-0.038	-0.051	-0.019
	(2.49)**	(3.70)***	(1.27)
Out materials (-2)	0.012	-0.036	-0.016
	(0.96)	(2.63)***	(1.1)
Out services	-1.086	-1.015	-0.966
	(6.06)***	(5.38)***	(4.39)***
Out services (-1)	-0.106	-0.469	-0.008
	(0.77)	(3.62)***	(0.06)
Out services (-2)	0.273	-0.336	-0.152
	(2.31)**	(2.87)***	(1.18)
Share R&D x dummy WC	-0.109	0.012	-0.014
	(2.96)***	-0.940	(1.03)
Out materials x dummy WC	0.091	0.067	0.064
	(3.89)***	(2.43)**	(2.08)**
Out services x dummy WC	1.749	0.991	0.740
	(8.84)***	(4.93)***	(3.26)***
Share R&D x dummy WC (-1)	-0.012	0.033	0.027
	(1.01)	(2.78)***	(2.19)**
Out materials x dummy WC (-1)	0.064	0.067	0.050
	(2.37)**	(2.66)***	(1.84)*
Out services x dummy WC (-1)	0.372	0.649	0.347
	(1.75)*	(3.31)***	(1.64)
Share R&D x dummy WC (-2)	0.006	0.026	0.008
	(0.56)	(2.51)**	(0.77)
Out materials x dummy WC (-2)	0.035	0.095	0.058
	(1.47)	(4.12)***	(2.34)**
Out services x dummy WC (-2)	0.508	0.468	0.192
	(2.87)***	(2.75)***	-1.060
Observations	416515	335395	335395
Number of groups	75722	63677	63677
AR (1)			0.000
AR (2)			0.595
JSCL Share RD x dummy WC	0.014	0.000	0.079
JSCL Out materials x dummy WC	0.000	0.000	0.000
JSCL Out services x dummy WC	0.000	0.000	0.000

Robust t statistics in parentheses
* significant at 10%; ** significant at 5%; *** significant at 1%
AR(i): autocorrelation tests of order i (p values) on the residuals
JSCL: Joint significance of contemporaneous and lagged , p values

Control variables are: age, age squared, week, week squared, tenure, tenure squared, dummies for year, regions, industry, firm size

Source: panel ISFOL on INPS data; Giorgio Rampa dataset; OECD STAN database.

Table 13: Estimation of elasticities from Table 12

Dependent variable: Real Wage	*FE*	*FD*	*2SLS*
Blue collars			
share RD, SR	-0.0006	0.0042	0.0024
	(0.19)	(69.34)***	(19.13)***
out materials, SR	-0.0230	-0.0147	-0.0112
	(52.26)***	(13.73)***	(6.16)**
out services, SR	-0.0200	-0.0191	-0.0182
	(36.71)***	(28.93)***	(19.28)***
share RD, LR	-0.0000	0.0025	0.0020
	(0.00)	(49.05)***	(10.00)***
out materials, LR	-0.0400	-0.0198	-0.0216
	(82.76)***	(34.24)***	(11.75)***
out services, LR	-0.0248	-0.0228	-0.0263
	(23.48)***	(43.55)***	(16.31)***
White collars			
share RD, SR	-0.0045	0.0046	0.0018
	(8.72)***	(75.93)***	(10.24)***
out materials, SR	-0.0073	-0.0031	-0.0001
	(3.38)*	(0.42)	(0.00)
out services, SR	0.0122	-0.0004	-0.0043
	(8.85)***	(0.01)	(0.74)
share RD, LR	-0.0061	0.0042	0.0030
	(7.63)***	(97.08)***	(16.01)***
out materials, LR	0.0077	0.0066	0.0154
	(2.17)	(2.33)	(4.07)**
out services, LR	0.0462	0.0036	0.0036
	(52.69)***	(0.64)	(0.21)

* significant at 10%; ** significant at 5%; *** significant at 1%
F statistics in parentheses (Chi squared for 2SLS)

Control variables are: age, age squared, week, week squared, tenure, tenure squared, dummies for year, regions, industry, firm size

Source: panel ISFOL on INPS data; Giorgio Rampa dataset; OECD STAN database.

To have a more realistic idea of the impact of innovation and fragmentation on real wages we refer to the 2SLS elasticities reported in Table 13. The economic relevance of the effects of outsourcing confirms the disparities between Blue and White Collars, since, if the share of services (materials) outsourcing will double, the former will experience an immediate cutting in real salaries of 1.8% (1.1%) and a long run reduction of 2.6% (2.2%). On the contrary, the effects on skilled workers will be much less dramatic, since the corresponding short reductions are not significant and the positive effect on the long term will be greater that 1.5% for materials outsourcing. Thus, the process of outsourcing is a source of increasing wage disparities, lowering the relative remunerations of low-skilled workers. On the other hand, the gain in productivity, due to the cost reduction assured by the outsourcing of part of the production process, will be translated in higher wages for skilled workers in the long run. Eventually, the magnitude of the impact of R&D expenditures on real wages is very low, ranging from an increase on 0.2% to 0.3% as a result of a doubling in RD.

Two additional aims of the paper are: 1) to evaluate if within industry reallocations have different impacts on wages with respect to the traditional wide measures of outsourcing, and 2) to ascertain whether the impact of fragmentation and innovation changes across industries. We investigate these hypothesis running the same regressions reported in Table 11 and, respectively, 1) using the narrow measure of outsourcing $OUTN$, instead of $OUTM$, and 2) disentangling for traditional and non traditional industries, defined according to the Pavitt classification and including in the advanced industries the specialized and scale economies industries.

With respect to the first point, Tables 15 and 16, reported in the Appendix, show that the wide and the narrow measure of industrial outsourcing give similar results. This finding is coherent with the high degree of correlation between the two measures (0.75) and also with the diagrams reported in Tables 7 and 9, showing a very close pattern in time evolution of the two indicators. In particular, comparing elasticities, it is possible to observe that also the narrow measure of fragmentation increases wage disparities, because of a negative (even if smaller than for the wide measure and significant a 10%) long run effect on Blue Collars wages and a positive elasticity on White Collars remunerations[22].

As regards the second exercise, Table 14 reports the estimates of elasticities for the two sub-samples of traditional and non traditional sectors[23]. This

[22]The effects of the other variables is mainly unaffected with respect to the specification including $OUTM$.

[23]The output of the regressions are not reported for reasons of space, but they are available on request from the authors. Given the similarity of previous results on $OUTM$

Table 14: Elasticities, traditional and non-traditional sectors

Dependent variable: Real Wage	*Traditional sectors*	*Non traditional sectors*
Blue collars		
share RD, SR	0.0023	0.0015
	(10.24)***	(1.74)
out materials, SR	-0.0190	-0.0231
	(9.12)***	(9.50)***
out services, SR	-0.0127	-0.0405
	(4.61)**	(37.91)***
share RD, LR	0.0054	-0.0017
	(27.25)***	(2.19)
out materials, LR	-0.0324	-0.0291
	(10.34)***	(8.47)***
out services, LR	-0.0167	-0.0426
	(2.49)	(17.39)***
White collars		
share RD, SR	0.0050	0.0022
	(17.48)***	(3.72)*
out materials, SR	-0.0058	-0.0055
	(0.21)	(0.44)
out services, SR	0.0031	-0.0240
	(0.16)	(12.65)***
share RD, LR	0.0107	0.0032
	(29.77)***	(5.18)**
out materials, LR	0.0137	0.0235
	(0.57)	(3.79)*
out services, LR	0.0254	-0.0228
	(3.29)*	(4.48)**

* significant at 10%; ** significant at 5%; *** significant at 1%
Elasticities are calculated from the 2SLS estimates of the dynamic model.
Chi squared statistics in parentheses.

Control variables are: age, age squared, week, week squared, tenure, tenure squared, dummies for year, regions, industry, firm size

Source: panel ISFOL on INPS data; Giorgio Rampa dataset; OECD STAN database.

simple decomposition conveys some interesting results:

1. R&D has a much larger impact on remunerations in traditional sectors, especially for white collars (a doubling of the share raises real wages by 1%);

2. Fragmentation of production has much more dramatic effect on low-skilled wages in non-traditional sectors, since elasticities account for a long-run wage reduction of 2.9% (4.3%) if the share of materials (services) outsourced is doubled;

3. The long run effect on White Collars salaries is no more neutral, given that, in non-traditional sectors, $OUTM$ has now a positive elasticity of 0.02 and $OUTS$ a negative elasticity of 0.02. Besides, this latter effect

and $OUTN$, we presents exclusively the decomposition by sector using the wide measure of outsourcing.

is roughly equal to its short run value, suggesting that there are no counterbalancing gains in productivity from outsourcing financial and business services in non-traditional sectors, since all wages are reduced. This finding could indicate that more advanced industries are reducing costs importing not only low skilled, but also high skilled functions from abroad[24]; and

4. Outsourcing in traditional sectors has smaller and less significant effects on compensations, apart from the quite large impact of $OUTM$ on unskilled workers.

In sum, the empirical analysis find that low-skilled wages always decreases in response to a raise in the share of outsourcing, either of materials or services, while the picture is more articulated for White Collars. In fact, the fragmentation of industrial production has a positive long run effect on their wages, probably because of productivity gains due to the lower costs of inputs, while the outsourcing of financial and business functions has a positive effect on traditional sectors and a negative one on more advanced industries.

A first suggested interpretation for these results could be that firms operating in traditional sectors outsource low quality services, while companies in non-traditional sectors will substitute more skill-intensive services abroad. More broadly, a possible suggestion coming from these results is that higher outsourcing could generally reduce the remuneration of Blue Collars because of the lower unions bargaining power. That effect, resulting from a rising fragmentation of production, could impinge more on unskilled than on skilled workers, because of different degree of coverage of collective agreements. As a result, the cost reduction due to outsourcing could favor mainly White Collars.

5 Conclusion

Low paid workers have faced a reduction in their real wages in relative terms and, in some cases, also in absolute terms. Two main factors have been considered in the economic literature in order to explain this trend: globalization and skill-biased technical change.

Our paper aims to give some empirical evidence on these relationships, using the R&D share on value added as a rough indicator of technological

[24]The FE results are consistent, instead, with a positive effect of both the kind of outsourcing.

improvements and using some measure of outsourcing (of materials, of business and financial services and the "narrow" outsourcing measure explained above) to evaluate the evolution of daily real wages for Blue and White Collars in the Italian manufacturing sector.

Because of the availability of data on wages, outsourcing and R&D, we consider the period 1985-1997, probably loosing major changes happened in more recent year. Nevertheless, even in that period many interesting conclusions may be drawn from our empirical analysis, which estimates both a static and a dynamic model of a standard wage equation, augmented by our key variable (R&D and outsourcing at industry level). Different estimators (Fixed Effects, First Differences, and Two Stages Least Squares) give generally similar results.

R&D shares generally affect positively real wages and this effects is stronger in the traditional sectors, especially for White Collars, while it seems that R&D does not affect manual workers wages in advanced sectors.

The outsourcing of materials and of financial and business services has a different effect on the remunerations of Blue and White Collars: whereas the former decreases, the latter remain stable (in the case of services outsourcing) or increases as a consequence of a raising fragmentation of production. According to our classification by industries, previous results are confirmed for unskilled workers, while some differences emerge for White Collars, especially in the case of business and financial services. Eventually, we used an alternative ("narrow") measure of outsourcing, which deals with within-industry trade, findings that it generally confirm the main results obtained with the "wide" measure of fragmentation.

The empirical elasticities calculated from the the 2SLS estimates (Table13) show that R&D intensity did not affect considerably wage disparities between skilled and unskilled workers in the period 1985-1997. On the other hand, the raise in materials and business and financial services outsourcing (respectively, 60% and 77% in the considered period) had a more considerable effect, increasing wage inequality by more than 4 percentage points overall.

Even if our findings seem to be consistent with expectations and some of previous literature results, and strong enough across different models specifications, further analysis are required. In particular, we should provide a theoretical framework and check the robustness of empirical results using the Difference-GMM techniques for dynamic panel data models.

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6 Appendix

Table 15: Estimation of equation 3 with interaction White and Blue collars

Dependent variable: Real Wage	*FE*	*FD*	*2SLS*
Real wage (-1)	0.230	-0.375	0.158
	(33.80)***	(61.85)***	(10.87)***
Real wage (-2)	0.088	-0.132	0.031
	(18.02)***	(30.78)***	(6.02)***
Dummy white collars	-0.016	0.046	0.044
	(2.68)***	(10.77)***	(8.70)***
Share R&D	-0.027	0.107	0.057
	(0.76)	(7.99)***	(3.96)***
Share R&D (-1)	0.016	0.000	-0.007
	(2.25)**	(0.03)	(0.97)
Share R&D (-2)	-0.002	-0.021	-0.018
	-0.350	(3.09)***	(2.40)**
Out materials	-0.113	-0.055	-0.034
	(5.77)***	(2.34)**	(1.26)
Out materials (-1)	-0.066	-0.058	-0.033
	(3.71)***	(3.51)***	(1.86)*
Out materials (-2)	0.028	-0.008	0.016
	(1.76)*	(0.51)	(0.88)
Out services	-1.041	-0.985	-0.944
	(5.81)***	(5.22)***	(4.28)***
Out services (-1)	0.310	-0.488	-0.046
	(2.62)***	(2.51)**	(0.34)
Out services (-2)	0.310	-0.292	-0.105
	(2.62)***	(2.51)**	(0.82)
Share R&D x dummy WC	-0.101	0.023	0.000
	(2.73)***	(1.90)*	(0.03)
Out narrow x dummy WC	0.072	0.027	0.006
	(2.70)***	(0.92)	(0.18)
Out services x dummy WC	1.689	0.928	0.662
	(8.52)***	(4.63)***	(2.91)***
Share R&D x dummy WC (-1)	-0.004	0.038	0.028
	(0.33)	(3.53)***	(2.39)**
Out narrow x dummy WC (-1)	0.073	0.054	0.060
	(2.63)***	(2.17)**	(2.18)**
Out services x dummy WC (-1)	0.427	0.661	0.413
	(2.00)**	(3.38)***	(1.95)*
Share R&D x dummy WC (-2)	0.001	0.028	0.011
	(0.13)	(2.81)***	(1.05)
Out narrow x dummy WC (-2)	0.065	0.112	0.065
	(2.56)**	(4.42)***	(2.36)**
Out services x dummy WC (-2)	0.566	0.560	0.272
	(3.20)***	(3.24)***	(1.48)
Observations	416515	335395	335395
Number of groups	75722	63677	63677
AR (1)			0.000
AR (2)			0.589
JSCL Share RD x dummy WC	0.048	0.000	0.020
JSCL Out materials x dummy WC	0.000	0.000	0.000
JSCL Out services x dummy WC	0.000	0.000	0.000

Robust t statistics in parentheses
* significant at 10%; ** significant at 5%; *** significant at 1%
AR(i): autocorrelation tests of order i (p values) on the residuals
JSCL: Joint significance of contemporaneous and lagged , p values

Control variables are: age, age squared, week, week squared, tenure, tenure squared, dummies for year, regions, industry, firm size

Source: panel ISFOL on INPS data; Giorgio Rampa dataset; OECD STAN database.

Table 16: Estimation of elasticities from Table 15

Dependent variable: Real Wage	*FE*	*FD*	*2SLS*
Blue collars			
share RD, SR	-0.0010	0.0040	0.0021
	(0.58)	(63.81)***	(15.70)***
out narrow, SR	-0.0151	-0.0075	-0.0046
	(33.29)***	(5.48)**	(1.59)
out services, SR	-0.0192	-0.0186	-0.0178
	(33.73)***	(27.23)***	(18.36)***
share RD, LR	-0.0007	0.0021	0.0015
	(0.15)	(36.62)***	(5.58)**
out narrow, LR	-0.0294	-0.0109	-0.0086
	(66.90)***	(14.60)***	(2.77)*
out services, LR	-0.0243	-0.0221	-0.0255
	(22.70)***	(41.04)***	(15.56)***
White collars			
share RD, SR	-0.0047	0.0048	0.0022
	(9.29)***	(84.93)***	(14.47)***
out narrow, SR	-0.0056	-0.0038	-0.0038
	(2.83)*	(1.03)*	(0.77)
out services, SR	0.0119	-0.0011	-0.0053
	(8.47)***	(0.06)	(1.15)
share RD, LR	-0.0063	0.0043	0.0033
	(7.82)***	(112.90)***	(21.20)***
out narrow, LR	0.0113	0.0065	0.0133
	(7.24)***	(3.85)**	(5.41)**
out services, LR	0.0482	0.0048	0.0059
	(57.47)***	(1.14)	(0.57)

* significant at 10%; ** significant at 5%; *** significant at 1%
F statistics in parentheses (Chi squared for 2SLS)

Control variables are: age, age squared, week, week squared, tenure, tenure squared, dummies for year, regions, industry, firm size

Source: panel ISFOL on INPS data; Giorgio Rampa dataset; OECD STAN database.