Individual Earnings, International Outsourcing and Technological Change. Evidence from Italy*

Chiara Broccolini, Alessia Lo Turco,
Andrea F. Presbitero, and Stefano Staffolani †

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Abstract

The aim of this paper is to empirically evaluate the relative effects of international outsourcing of materials and services and of ICT capital deepening on wage inequality between blue and white collars in the Italian manufacturing industry during the period 1985-1999. We merge an administrative data set on workers' wages and individual characteristics with data on imported inputs from Italian input-output tables and other sector-level variables. Our results confirm that both material and service outsourcing widen the skilled/unskilled wage gap while ICT capital deepening positively affects real wages regardless of the worker's status. However, important differences emerge when the overall sample is split between traditional and innovative sectors.

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1 Introduction

Two competing and possibly complementary phenomena contribute to explain the observed raising inequality between skilled and unskilled workers

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†Affiliation for all Authors: Department of Economics - Università Politecnica delle Marche. Corresponding Author Chiara Broccolini, c.broccolini@univpm.it

within a nation's boundaries. Both the increasing presence of developing and transition countries in the international production networks and the fast advances in the Information and Communication Technology (ICT) have radically modified the production systems. Several are the consequences of such changes in production and the increase in wage inequality in developed countries has been deeply investigated, in particular with reference to the U.S. economy.

Technological change has been indicated as the driving force explaining the pattern of wages in developed countries. Gathering some stylized facts for the U.S. economy, Acemoglu (2002) develops a unifying theoretical framework in which the behavior of technological change can be understood recognizing that the development of new technologies is, in part, a response to profit incentives. 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. Hence, recent technological developments have affected the organization of firms, of labor markets and of labor market institutions, resulting in large effects on wages[1].

Nevertheless, the increasing fragmentation of production with the bursting of trade in intermediates can be an alternative explanation for wage inequality (Feenstra, 1998). Feenstra and Hanson (1996, 1999) initially focused on international outsourcing as the main cause for the rising relative demand for non-production workers[2] and only later extended the analysis including the role of technological progress. The empirical results from this extension ended in a positive and significant role for outsourcing in explaining the wage gap (almost 40% of the observed wage gap) between skilled and unskilled although, in some specifications, the role for technological change turns out to be more important (about 75% of the observed wage gap)[3]. This factor bias effect of international outsourcing hinges on the hypothesis of a single good and two factors of production, skilled and unskilled labor. Arndt (1997) challenges this conclusion and shows how the factor bias of

[1]Machin and Van Reenen (1998) 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. More recently, Bratti and Matteucci (2005) point out that the evidence in favor of SBTC for European countries is less straightforward. For further refinements on the relation between technological change and wage inequality see, among others, Aghion et al. (2002) and Borghans and ter Weel (2004).

[2]They found that the change in outsourcing can account for 30 to 50% of the increase in the non production workers' relative wage in the USA manufacturing sectors in the period 1979-1990.

[3]The result, though, is sensitive to the measure of IT capital adopted and sometimes bears a smaller effect of the latter variable with respect to the effect of international outsourcing.

international outsourcing can turn into a sector bias if a two sectors two factors Heckscher-Ohlin framework is considered. The expansion of production in the outsourcing sector allows for an increase in the demand and, subsequently, in the wage for low skilled workers in low skill-intensive industries. Then, inequality between skilled and unskilled is reduced and what matters for the increased wage inequality outcome is the skill intensity of the sector engaged in outsourcing[4]. More recently, Grossman and Rossi-Hansberg (2006) move to the definition of production technologies in terms of tasks and in the same direction show that offshoring[5] need not be detrimental for low skilled workers however this is not always the case when final good prices decline (Kohler, 2008).

From the above discussion, the effect of international outsourcing and technological change is an empirical matter. Chusseau, Dumont e Hellier (2007) survey the effects of SBTC and international trade on wage inequality claiming that both phenomena are relevant although their effects change across countries and sectors. Furthermore, international outsourcing appears as the main trade component at the basis of the growing demand for skilled labor and could represent one of the main sources of polarization in U.S. wages out of the traditional SBTC explanation which appears to be inadequate(Autor, Katz e Kearney 2008). As concerns the European experience, a number of papers focus on the relation between the relative demand for skilled labor and international outsourcing at the sector level (Hijzen, Holger and Hine, 2004 for the U.K. economy; Strauss-Kahn (2003) for French manufacturing; Helg and Tajoli (2005) for Italy and Germany) and convey evidence of a positive effect of outsourcing on the relative demand for skilled labor. Hijzen (2007) highlights the relative importance of the impact of outsourcing and technological change on wage inequality in the UK during the 1990s, using industry-level data. His findings suggest that international outsourcing plays a role in explaining the wage gap, even if the most important force shaping the increase in wage inequality is technological change.

Similarly to the approach adopted in this paper, Geishecker and Gorg (2008a) investigate the link between outsourcing and wages using a large household panel and combining it with industry level data. They point

[4]Egger and Falkinger (2001) develop a complete characterization of the distributional effects of international outsourcing in the Heckscher-Ohlin framework where the factor and sector bias are reconciled according to a final equilibrium with specialization or diversification. Kohler (2002), instead, proposes a specific factor model allowing for the possibility of a welfare reducing effect of outsourcing for the domestic economy, even without any market distortion.

[5]In the debate on the effects of the international fragmentation of production the terminology has undergone some changes, however to the purpose of this work the term offshoring and international outsourcing are considered as synonymous in that they both refer to moving parts of the production process abroad either to foreign sub-contractors or to a foreign affiliate of the domestic firm.

out that industry level studies are actually affected by an endogeneity bias which can be overcome using individual wages. For this reason they estimate a wage equation introducing the sectoral outsourcing of materials and R&D intensity as additional regressors showing that outsourcing negatively affects low skilled workers' real wage and produces some gains for skilled workers.

Falzoni et al. (2004) explore the relation between international trade, factor mobility and inequality for Italy using regional data on manufacturing earnings of skilled and unskilled workers between 1991 and 1996. They also control for SBTC creating an index which ranks manufacturing sectors according to Pavitt's classification. Their results show that international trade in goods reduces wage differentials through a positive impact on the wage of the unskilled: the growth of exports and imports increases blue collars'wage while immigration increases inequality. The technology effect captured by the mentioned index is not significant. The result on blue collars' wages is related to Italian specialization in unskilled labor intensive productions. Always for Italy, Falzoni e Tajoli (2008) highlight the absence of an effect of fragmentation of production on overall sectoral employment, while the effect is positive and slightly significant for the relative demand of the skilled.

In order to contribute to the empirical literature on the effects of international outsourcing and technological change on wage inequality, this work focuses on the case of Italy between 1985 and 1999. Although disparity in real wages among skilled and unskilled workers in Italy has increased moderately with respect to other developed economies, the process of delocalization of manufacturing production towards cheaper labor locations has been relevant, especially for more traditional sectors. By the same token, the ICT capital deepening has represented an important, although slower, transformation for Italian manufacturing. Then, despite the rather rigid institutional framework, we believe that these two phenomena have played a determinant role in affecting individual wages and the yet little change in inequality across workers' categories. These issues are particularly relevant to guide future industrial and labor policies and what remains to establish is which of the two "revolutions" prevailed, having care to disentangle possible heterogeneous responses across sectors.

We follow Hijzen (2007), focusing on outsourcing and technological change as simultaneous sources of wage inequality, while we build on Geishecker and Gorg (2008) , using a large panel of individuals to avoid the endogeneity bias of sectoral studies. Differently from the previous studies, we drop the use of R&D and we measure technological change by means of ICT capital per worker and, relying on information from Italian input-output tables, we directly use the data on imported intermediate inputs with no need to attribute a share of total imports to imports of intermediates. We focus on outsourcing instead of overall trade[6] and we do not limit the analysis of outsourcing in Italy to Outward Processing Trade (OPT), since we include all imported intermediate inputs and not only re-imports[7]. For the first time to our knowledge, we also consider the outsourcing of business and financial services. To obtain robust results, we control for other sectoral time varying factors (sectoral productivity and skill intensity) and for other unobserved effects that might drive the wage gap (e.g. change in labor market institutions). A last refinement consists in considering heterogeneous inequality effects of international outsourcing and ICT capital deepening across sectors.

Our results, in general, confirm that both material and service outsourcing widen the skilled/unskilled wage gap while ICT capital deepening positively affects real wages regardless of the worker's status. Important differences emerge when the overall sample is split between traditional and innovative sectors. Material outsourcing plays a major role in explaining the wage gap in traditional sectors, while the outsourcing of business and financial services dramatically affects it in innovative sectors. ICT capital deepening only matters for inequality in innovative sectors. Finally and differently from the the general findings in the literature (Feenstra and Hanson, 1999, Hijzen, 2007) the size of the effect of technological change is lower than the size of the effect of international outsourcing.

The paper is organized as follows: Section 2 presents the data sets and the variables; Section 3 discusses the empirical model; Section 4 presents the results, and Section 5 discusses the findings and concludes. Tables and Figures are reported in Appendix A.

2 The Data

To analyze the impact of outsourcing and ICT on individual wages and wage inequality, we build a database for more than 120,000 workers observed from 1985 and 1999, merging three different data sets which contain information on individual wages, sectoral ICT, productivity and 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[8], weeks and days of work, gender, age, qualification, region of the workplace, firms' sector and size are available but, unfortunately, tenure, educational levels, daily working hours, family composition and family background are missing.

[6] As in the paper by Falzoni et al. (2004) do.

[7] Helg and Tajoli (2005) use this very narrow definition of outsourcing which only conveys information on manufacturing re-imports.

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

In this work, we employ a sample of the whole data set, rearranged by ISFOL[9], which collects information on every workers born the 10^{th} of March, June, September and December of each year. Thus, 1 worker out of about 91 is included in the sample and the whole data set is composed by more than 2,100,000 observations[10]. 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[11]. Besides, daily wages, firm's sector and size of workers with more than one job during the same 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, corresponding to 5,655 and 1.866 euro 1997 respectively) and workers who did not work during the whole year.

Furthermore, we only consider primary workers, i.e. male workers aged between 30 and 55: the increasing presence of female and young workers in the original data set might produce a distortion due to these workers' preference for part-time. Finally, we drop observations referring to individuals working in the service sectors in order to focus the analysis on manufacturing.

Table 1 shows the number of observations in our (unbalanced) panel, by year and skills defined as Blue Collar (BC) and White Collar (WC) from the division between production and non-production workers. They refer to 48,280 workers: 4,032 of them are observed for each year and, while median of the presence in the data set is 5 years and the average is 5.4 years.

We measure the intensity of outsourcing calculating two alternative sector level indicators for material outsourcing and a third one for financial and business services outsourcing, using data drawn from the Italian input-output tables elaborated by Giorgio Rampa[12]. Despite the recent availability of ISTAT input-output tables for the period 1995-2004, the availability of administrative data on workers up to the year 1999 would leave us with only 5 years of matching and this leads us to prefer the use of the Rampa's elaborations of input-output tables for Italy, which allow us to observe the relation between offshoring and wages within the longer 1985-1999 time span.

Furthermore, differently from ISTAT *use* tables, Rampa's tables are symmetric and give the branch-to-branch technological relation instead of the product-to-branch one so that intermediate inputs come exactly from the same branch and not from the same product regardeless of the branch. Fi-

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

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

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

[12] The dataset is available at $http://www.giuri.unige.it/iotables/index.html$.

nally the classification of the economic activity of the workers'employers is ATECO81 and is easily reconciled with the classification of Rampa's tables (ESA1979)[13].The only shortcoming is that the definition of business services is not relly detailed. To reckon the degree of material outsourcing, we employ a "narrow" indicator, defined, in accordance to the previous literature (see Feenstra and Hanson, 1999), as:

$$OUT_{jt}^{NAR} = \frac{\tilde{X}_{jjt}}{\sum_{i=1}^{n}(X_{jit} + \tilde{X}_{jit})} \qquad for \qquad j = 1, ..., m \tag{1}$$

where X_{jit} ($\tilde{X}_{jit}$), for each sector j, represents the cost for intermediate inputs from the home (foreign) sector i at time t, n represents the number of sectors in the economy (excluding energy and primary sectors), and m represents the number of sectors in manufacturing. In other words, this is a measure of within industry intermediate inputs substitution, since it represents the share of intermediate costs which is shifted to the same industry abroad.

To measure the overall intra- and inter-industry substitution process brought about by outsourcing, we also calculate a "broad" measure of material outsourcing for sector j, which refers to the overall imported inputs from all manufacturing sectors abroad:

$$OUT_{jt}^{MAT} = \frac{\sum_{i=1}^{m}\tilde{X}_{jit}}{\sum_{i=1}^{n}(X_{jit} + \tilde{X}_{jit})} \qquad for \qquad j = 1, ..., m \tag{2}$$

Eventually, the outsourcing of services in sector j at time t is defined as the total business and financial services purchased from abroad over total non energy and non primary intermediate inputs:

$$OUT_{jt}^{SER} = \frac{\sum_{i=m+1}^{n}\tilde{X}_{jit}}{\sum_{i=1}^{n}(X_{jit} + \tilde{X}_{jit})} \qquad for \qquad j = 1, ..., m \tag{3}$$

Moving to our second variable of interest, the extent of ICT capital deepening is measured as:

$$ICT_{jt} = \frac{ICTcap.stock_{jt}}{E_{jt}} \qquad for \qquad j = 1, ..., m \tag{4}$$

[13]Checking the consistency of the information coming from the two sources is a hard task because of large differences in the two original classification systems, however it is worth to mention that Lo Turco (2007) uses the Rampa's data to explore the productivity effects of offshoring in Italian manufacturing sectors in the period 1985-1997 and, later on, Daveri and Jona-Lasino (2008) use ISTAT tables to repeat the same exercise for the 1995-2004 period: the quantification of the productivity effect of international outsourcing of materials is exactly the same in both papers regardless of the sources of the data adopted and the qualitative implication for the outsourcing of services is analogous. The future availability of a longer time span of data on workers will allow us to compare the results from the following analysis with the ones obtained using ISTAT tables.

where $ICTcap.stock_{jt}$ represents the software, office and communication real capital stock and E_{jt} measures the total sector employment. The information on ICT capital stock comes from the ISTAT National Accounts, while sector employment are drawn from the OECD-STAN database. We also include two more industry specific time-varying controls. The logarithm of the sector real value added per worker (VA) is added as a proxy for sectoral productivity and is reckoned from the OECD-STAN data deflated using the consumer price index (drawn from ISTAT). Finally, the skill intensity ($SKILL\_INT$), measured as the logarithm of the share of non production workers in total workforce by region and industry in each year, is meant to proxy for changes in the structure of the labor force.

The analysis of the temporal and sectoral distribution of our key variables is shown in Tables 2 and 3. The average real wage grew steadily until 1991. From 1992 onwards, the effect of the lira crises and the loss of competitiveness together with the negotiation of the "Protocollo sulla politica dei redditi e dell'occupazione" (signed in 1993 by the government and social partners), that introduced the method of "concertazione" and the two-tier bargaining system, both at sectoral and firm level, probably played a role in the real wages reduction occurred until 1996. The "narrow" measure of material outsourcing[14] increases in the period under analysis, partially reflecting the trend emerging for the "broad" measure of outsourcing, while the intensity of imported business and financial service inputs nearly doubled during the sample period, even if it is much smaller than the other indicators.

Across sectors, the outsourcing of materials, both in the narrow and broad measure, is more pronounced in the Chemicals and Pharmaceutics, Office, Optical and precision equipment, Electric equipment, Meat, Milk products and Leather. ICT capital per worker is higher than the average in more innovative sectors, such as the Chemicals and Pharmaceutics, Office, Optical and precision equipment, Electric equipment and Motor vehicles and transport equipment. The classification of sectors as "Traditional" or "Innovative" follows the one in Lall (2005): the 19 ateco-81 sectors are classified as *Innovative* according to the existence of economies of scale and to the technological content of their typical activities; the remaining sectors are classified as *Traditional*. However, we checked if the adoption of this classification was suitable for Italian sectors and compared it to the one obtained by ranking sectors according to the skill intensity above or below the mean and the two classifications coincide.

To sum up, Table 4 shows that, on average, the gap in real wages has grown by about a 9%, with a slightly higher rate in traditional sectors. Material outsourcing increased by about 54%, when measured according to

[14]In the descriptive analysis, the indicators of outsourcing and capital deepening are in levels and not in logarithm, in order to be more readable.

the narrow definition, with an even faster pace in innovative sectors. The outsourcing of business and financial services grew by 70%, with many innovative sectors displaying shares above the overall manufacturing average. It is worth noting that for both material and service outsourcing the temporal evolution shows an acceleration at the beginning of the 1990s (see Table 2). The ICT capital per worker experienced the most striking growth, more than doubling during the sample period, especially in innovative industries.

Coming to the other possible determinants of the wage gap, sectoral productivity grew on average by around 14% and the skill intensity by about 30%, the former though increased more in innovative than in traditional industries and the opposite holds true for the latter. Eventually, the evolution of total employment was highly skewed towards innovative sectors (+26% with respect to +6.9% in traditional sectors) and employment of blue collars experiences e very modest growth especially in Traditional sectors.

3 The Empirical Model

The empirical model is a standard wage equation (see, among others, the seminal contribution of Mincer (1974)), in which we add the outsourcing and the ICT variables among the right hand side regressors. The basic specification of the wage equation for the panel data set is given by:

$$\begin{aligned} w_{ijt} = \alpha_0 + \alpha_1 I_{it} + \alpha_2 OUT_{jt} + \alpha_3 ICT_{jt} + \\ + \alpha_4 WC_{it} + \alpha_5 Z_{jt} + \tau_j + \mu_t + \iota_i + \epsilon_{i,t} \end{aligned} \tag{5}$$

where, w_{ijt} is the log of the daily real wage of individual i employed in the industry j at time t, I_{it} is a set of variables measuring individual, demographic and work features for individual i at time t, that I_{it} includes

- individual specific data: age, number of days worked per year, their squared values to account for nonlinearities;
- work specific data: firm's size and the region where the firm is located.

With respect to our key variables, OUT_{jt} contains the outsourcing intensities of materials and services of industry j at time t, ICT_{jt} denotes the ICT capital stock per worker and WC_{it} is a dummy for white collars[15]. Finally, Z_{jt} is a vector of the further industry specific variables, mentioned in the previous section, which could affect the wage gap (i.e. sector productivity, VA_{jt} and skill intensity, $SKILL\_INT_{jt}$). Eventually, τ_j represents industry specific effects[16], ι_i are time invariant individual effects, μ_t are time specific

[15] We take the natural logarithm of the share of outsourcing as previously defined and of the other variables introduced below, so that we can easily interpret their estimated coefficient as elasticities. However, we will also check for the robustness of our results using the linear and the logistic transformation of these variables .

[16] 19 sectors, according to the ateco 81 classification, 2 digits

effects, and $\epsilon_{i,t}$ is an idiosyncratic shock affecting individual wage at time t.

To study the relation between outsourcing, technological change and wage inequality, we follow two strategies. Firstly, we include in equation 5 the interaction terms between the WC dummy and our variables of interest. To control for other sector specific time-varying phenomena which might drive the inequality outcome, skill intensity and sector productivity are also interacted with the WC dummy. Eventually, we control for other unobserved sources of wage inequality interacting the skill dummy, WC, with industry, year, region and size dummies. In particular, the interaction between the year dummies and the WC dummy is meant to allows for institutional changes affecting the wage gap in the period under analysis. As a result, equation 5 is modelled as:

$$\begin{aligned} w_{ijt} = \alpha_0 + \alpha_1 I_{it} + \alpha_2 OUT_{jt} + \alpha_{2I} WC_{it} \cdot OUT_{jt} + \alpha_3 ICT_{jt} + \\ + \alpha_{3I} WC_{it} \cdot ICT_{jt} + \alpha_4 Z_{jt} + \alpha_{4I} WC_{it} \cdot Z_{jt} + \\ + \beta_1 \tau_j + \beta_{1I} WC_{it} \cdot \tau_j + \beta_2 \mu_t + \beta_{2I} WC_{it} \cdot \mu_t + \iota_i + \epsilon_{i,t} \end{aligned} \quad (6)$$

Secondly, to test the robustness of our findings, we estimate equation 5 for the two sub-samples of blue and white collar.

Equations 5 and 6 could be estimated with standard Fixed (FE) or Random Effects (RE). We perform the Hausman test, rejecting, in both cases, the null hypothesis[17]. Thus, we will generally present the results obtained using the Least Square Dummy Variable (LSDV) estimator[18].

We test for the presence of serial correlation following a solution proposed by Wooldridge (2002) and implemented in Stata by Drukker (2003), based on the AR(1) serial correlation of the residuals obtained from the estimation of model 5 in first difference. Since the test rejects the null hypothesis, we will estimate equation 5 using the variance-covariance matrix corrected both for heteroskedasticity and serial correlation.

4 Results

Table 5 presents the relevant coefficients of the estimation of equation 5[19]. Columns (1) to (4) show the fixed effect estimates: we start including only the outsourcing variables and, then, we add ICT, VA and $SKILL\_INT$ in order to check the robustness of the findings to the inclusion of further sector level controls.

[17] This results is also consistent with the *a priori* that, in our specification, the additional hypothesis required by the RE of no correlation between the unobserved effects (i.e. education, innate ability) and the explanatory variables is likely to fail.

[18] The results of these tests are available from the Authors, on request.

[19] The complete estimation include a set of control variables available in the data set, namely workers age (linear and squared), days worked (linear and squared), regional, yearly, firm size and sectoral dummies.

In what follows we refer to material outsourcing considering the “narrow” indicator (equation 1), but similar results are obtained substituting this measure with the “broad” one[20]. Our results show that wage inequality is widened by international outsourcing, while ICT capital deepening does not have any significant effect on the wage gap. Specifically, the coefficients on material and service outsourcing are stable across different specifications (columns (1)- (4)). OUT^{NAR} has a significant and positive effect only on the wages of skilled workers, while OUT^{SER} reduces the blue collar wages and raises the remuneration of the skilled, with an elasticity that is twice larger than the one of material outsourcing. ICT capital deepening raises the average wage, but it does not have any significant heterogeneous effect according to workers' status. Finally, sectoral productivity is related to wage dispersion, since the white collars' wage increases more than the average one, and the indicator of sectoral and regional skill intensity is not significantly related to real wages.

In column (5) we report the Random Effects estimates: there are no relevant differences in the magnitude and significance of the coefficients of our key variables, apart from $SKILL\_INT$ which now has a positive (but limited) impact on real wages. However, the Hausman test rejects the null hypothesis and we focus on the FE estimates.

The main assumption in the estimation of the empirical model is that sector level outsourcing and ICT capital deepening are exogenous with respect to individual earnings. An endogeneity bias might arise if the decision of firms to relocate production abroad and/or to invest in ICT are affected by the evolution of individual wages.

In Italy industry wages are mainly based on national contracts and this could influence firms' decisions to relocate production abroad and to invest in ICT. Nevertheless, a relevant heterogeneity remains across individual wages because of personal and territorial features. Therefore, sector level phenomena can be considered exogenous with respect to each individual wage history. However, we perform the C-test statistic to test for the endogeneity of OUT^{NAR} OUT^{SER} and ICT (column (4), last row). The failure to reject the null hypothesis supports the treatment of the variables as exogenous.

The last two columns show the results obtained separately estimating equation 5 for the two sub-samples of traditional and innovative sectors, in order to ascertain if outsourcing and technological change have heterogeneous impacts on wage dispersion in different industries, according to their degree of innovative capacity. The estimates points out interesting differences since material outsourcing only affects inequality in traditional sectors while service outsourcing does so in the innovative ones. As expected, the role of ICT capital deepening is only relevant for disparities in innovative

[20]Results are not reported for the sake of brevity, but they are available from the authors upon request.

sectors. The detailed results are as follows[21]:

- material outsourcing has a much larger impact on wage inequality in traditional sectors than on average, since it lowers the blue collar wages and raises the white collars' ones by almost the same amount. In innovative sectors, instead, OUT^{NAR} has a positive effect exclusively on the average real wage.

- service outsourcing has a strong effect on wage inequality in innovative sectors, since the elasticities are twice as larger than on average both for white collars (+0.048) and blue collars (-0.041) wages. In traditional sectors, on the other hand, an increase in OUT^{SER} lowers real wages regardless of worker's status.

- ICT capital deepening, which does not affect the average level of inequality (columns (2) - (4)), turns out to increase wage dispersion in innovative industries, where it lowers the BC wages, leaving roughly unaffected the WC wages. In traditional sectors, ICT contribute to a widespread growth in remunerations.

The last rows of column (6) in Table 5 display the Wald test and P-value for equality of coefficients across the two subgroups of sectors: the null is strongly rejected providing evidence of heterogeneity of the effects of outsourcing and ICT according to the typical content of the activities performed.

Table 6 reports the results of the fixed effects estimation of equation 6 separately for white and blue collars. The first two columns refer to the overall sample, while the other columns make a distinction between traditional and innovative sectors. The results generally confirm the ones obtained by the general model 5, in which we model heterogeneity including interaction terms between our key variables and WC. In this case, we allow for the model to be completely different according to workers status: the fact that our main findings are unaffected is an indication of the robustness of our results. Furthermore, the last rows display the Wald test for the equality of coefficients across the two sub-samples of blue and white collars. The null hypothesis is always strongly rejected confirming that the effects of the explanatory variables on individual wages are significantly different according to workers' status. Specifically, the fragmentation of production generally contributes to the wage gap, with the most relevant effect due to outsourcing of business and financial services in innovative sectors. Technological change produces an effect on real wages which is somewhat smaller than the one of

[21] As regards industry level controls, sectoral productivity in general is related to an increase in wages, although it is associated with an increase in the wage gap in the innovative sectors. The degree of skill intensity has a limited effect only on wage inequality in traditional sectors, where it raises the daily real wage of skilled workers.

outsourcing and its impact on the wage gap is limited to innovative sectors. The role of outsourcing of business and financial services in explaining the wage gap is in line with the one observed by Geischecker and Gorg (2008b) for the U.K. economy. Our results are robust to a number of modifications of the empirical model and to different definitions of outsourcing and ICT[22]. As regards model specification, the one-by-one exclusion of some of the sectoral controls does not change the size and significance of the effects of ICT and outsourcing. Furthermore, results are consistent even taking either the linear or the logistic transformation of the shares of material and service outsourcing and of the share of non production workers in total workforce. With respect to alternative indicators of outsourcing and capital deepening, we replace the "narrow" indicator with the "broad" one (OUT^{MAT}) without affecting significantly our findings. Alternative definitions of ICT as (1) the logarithm of the ratio between the ICT real capital stock and the sector value added, and (2) the share of ICT capital compensation in total capital compensation (data drawn from the EU KLEMS database) do not substantially change the results.

5 Discussion and Conclusions

The focus of this work has been on the relative impact of international outsourcing of materials and services and ICT capital deepening on skilled/ unskilled wage inequality in Italy.

The case of Italy can be considered an interesting one since relevant changes have occurred in manufacturing due to the delocalization of production towards low wage cost locations. ICT capital deepening has also reshaped the organization of firms in Italian manufacturing, and the gap in real wages between skilled and unskilled has increased during recent years. A large panel of workers has been combined with sector level data on international outsourcing and ICT capital stock producing a unique and wide data set where the wage disparity evolution has been observed between 1985 and 1999, a relevant period for the changes undergone in the Italian manufacturing. Besides, a measure of sectoral productivity and one capturing the degree of skill intensity, together with interactions of both time and industry dummies with worker's status are meant to control for further observables and unobservables driving the inequality outcome.

Apart from the focus on both international outsourcing and ICT, which allows for conveying information on their relative importance in affecting the wage gap, the present paper adds to the existing empirical literature providing evidence on their heterogeneous effects across workers and sectors. In this respect, although international competition and technological

[22]Results are not reported for the sake of brevity, but they are available from the authors upon request.

progress have strongly stimulated the general reorganization of production in Italian manufacturing, the responses of traditional and innovative sectors have been different, with the former looking for cost saving and the latter for technology.

In general, our results are consistent with the idea that international outsourcing was one of the determinants of the broadening wage gap between skilled and unskilled Italian workers in the period 1985-1999. The real wage ratio, in fact, increased on average from about 1.43 to around 1.58 during the sample period. To have an idea of the economic contribution of outsourcing and ICT capital deepening on the evolution of the wage ratio, we present its observed path, the one predicted by the model 5, and the ones calculated with outsourcing and ICT shares constant at their 1985 values. Figure 1, other than showing the good fit of the model, points out that international outsourcing is a relevant factor for explaining the evolution of wage inequality, while, on aggregate, SBTC did not contribute to wage dispersion. More precisely, the impact of outsourcing started in the 1990s, in accordance with the raise in the share of OUT_MAT and OUT_SER (see Table 2), and, in the end, accounted for more than one third of the wage ratio growth.

Figure 2, built in the same way as Figure 1, investigates the possibility that technological change and international outsourcing have different effects on the wage gap in traditional (left panel) and innovative (right panel) sectors. As one could see, the evolution in traditional sectors mimics the one for the entire manufacturing industry, while the picture is somewhat different for innovative sectors, as results from the estimation of the wage equation. More specifically, the wage ratio increases from 1.41 to 1.55: in this case both technological change and international outsourcing contributed to the wage gap, even if the latter is the predominant force. On the one hand, the effect of ICT capital deepening accounts for around 0.03 points out of the 0.14 points increase in the wage ratio and its contribution is pretty stable and increasing through time. On the other hand, the impact of outsourcing seems to start in the 1990s and it accounts for 0.08 points. Hence, international outsourcing and ICT capital deepening together explain a large part of the widening wage dispersion in innovative sectors, with the former being the most relevant factor. Despite this result is somewhat reversed with respect to the existing empirical evidence concerning other economies (Feenstra and Hansen, 1999, for the U.S. and Hijzen, 2007, for the UK) it can be related to the slower pace of the ICT "revolution" compared to the increasing importance of vertical disintegration in the organization of firms in Italy.

Cost saving together with a reduction in the weight in total employment is consistent with our result on increased inequality in traditional sectors mainly driven by the outsourcing of materials. The factor bias effect of international outsourcing of material has resulted in the upgrading of jobs within the sector and to a decline in the relative real wage of the unskilled. Technological change increases the average wage, but it is neutral with respect to the workers' status in the Italian traditional sectors.

For the innovative sectors, the search for productivity improvements together with the increase in the relative weight in manufacturing employment is in line with the observed increased inequality related more to the outsourcing of business and financial services and ICT capital deepening.

Whether high or low skill intensive, the dramatic increase in the outsourcing of business and financial services together with the growth in the relative weight of innovative sectors in total manufacturing employment could reproduce the inequality result studied by Arndt (1997). If it is the high skill intensive sector to send abroad part of production, the relative wage for skilled workers increases.

The results from this research naturally lead to some future developments in the study of the consequence of international outsourcing and ICT on the stability of wages and employment across sectors and workers' status. Particular attention needs to be devoted to the role of the outsourcing of business and financial services: a finer definition of services might in fact reveal whether outsourcing of services actually could represent another source of technological change.

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A Tables and Figures

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

year	Blue Collars	White Collars	Whole Sample
1985	12874	3968	16842
1986	15797	5280	21077
1987	15544	5330	20874
1988	15371	5415	20786
1989	14992	5515	20507
1990	14092	5257	19349
1991	14594	5559	20153
1992	14329	5483	19812
1993	15354	5896	21250
1994	15384	5960	21344
1995	15670	5961	21631
1996	16192	6047	22239
1997	16001	6057	22058
1998	15287	5836	21123
1999	14711	5679	20390
Total	226192	83243	309435

Source: panel ISFOL on INPS data.

Table 2: Daily Real Wages, Outsourcing indicators, yearly averages

Year	Real wage	"Narrow"material outsourcing	"Broad"material outsourcing	Services outsourcing	ICT
1985	35.165	0.106	0.181	0.015	1.022
1986	35.910	0.116	0.188	0.016	1.226
1987	37.026	0.115	0.186	0.016	1.355
1988	37.590	0.113	0.186	0.013	1.491
1989	38.357	0.114	0.190	0.013	1.584
1990	38.793	0.112	0.186	0.018	1.610
1991	40.019	0.116	0.190	0.017	1.629
1992	39.839	0.118	0.191	0.025	1.675
1993	39.352	0.127	0.200	0.026	1.694
1994	39.108	0.149	0.226	0.024	1.783
1995	38.496	0.169	0.250	0.022	1.933
1996	38.130	0.159	0.232	0.023	1.997
1997	39.059	0.162	0.238	0.024	2.147
1998	39.587	0.168	0.248	0.026	2.249
1999	39.922	0.170	0.248	0.027	2.276
Total	38.456	0.135	0.210	0.020	1.724

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

Table 3: Daily Real Wages, Outsourcing and ICT indicators, averages by sectors

Sector Ateco 81	Description	Lall's classification	Real wage	"Narrow" material outsourcing	"Broad" material outsourcing	Services outsourcing	ICT
13	Ferrous and non-ferrous metals	innovative	40.372	0.288	0.298	0.020	2.432
15	Non-metal mineral products	innovative	35.627	0.063	0.087	0.011	0.495
17	Chemicals and pharmaceutical products	innovative	46.762	0.276	0.294	0.014	4.090
19	Metal products	traditional	35.993	0.015	0.102	0.029	0.682
21	Industrial and agricultural machineries	innovative	39.851	0.141	0.202	0.030	1.290
23	Office, optical and precision equipment	innovative	47.824	0.275	0.394	0.024	4.515
25	Electric equipment	innovative	38.888	0.216	0.286	0.025	4.864
27	Motor vehicles and engines	innovative	38.108	0.100	0.204	0.013	2.151
29	Other transport equipment	innovative	38.820	0.133	0.227	0.026	3.756
31	Fresh and preserved meat	traditional	35.038	0.223	0.229	0.041	0.586
33	Milk and milk products	traditional	38.948	0.402	0.405	0.016	0.580
35	Other food products	traditional	38.716	0.060	0.089	0.009	0.590
37	Drinks	traditional	41.459	0.016	0.085	0.017	0.577
41	Textiles and clothing	traditional	36.041	0.150	0.204	0.018	0.528
43	Leather, leather products and footwear	traditional	30.267	0.185	0.304	0.017	0.415
45	Wood and furniture	traditional	29.320	0.133	0.152	0.007	0.891
47	Paper, printing and publishing	innovative	41.927	0.173	0.193	0.010	1.293
49	Rubber and plastics	innovative	37.374	0.094	0.329	0.013	0.856
51	Manufacturing,nec.	traditional	38.434	0.010	0.373	0.050	1.011
Average			38.454	0.135	0.210	0.020	1.724

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

Table 4: Variation rate in the period 1985-1999

	All economy	Traditional sectors	Innovative sectors
Wage gap	0.090	0.091	0.089
“Broad” materials outsourcing	0.291	0.145	0.423
“Narrow” materials outsourcing	0.539	0.420	0.647
Services outsourcing	0.700	0.752	0.652
IT Capital deep.	1.603	1.504	1.693
Per capita Value Added	0.140	0.107	0.170
Skill Intensity	0.316	0.435	0.209
Total employment	0.173	0.069	0.267
Total employment-White Collars	0.331	0.195	0.453
Total employment-Blue Collars	0.089	0.030	0.142

Source Panel ISFOL on INPS data; Giorgio Rampa dataset; OECD STAN database; ISTAT National Accounts. Own calculations.

Table 5: Estimation of equation 6

Dep. Var.: $WAGE$	(1) FE All sector	(2) FE All sector	(3) FE All sector	(4) FE All sector	(5) RE All sector	(6) FE Traditional	(7) FE Innovative
OUT^{NAR}	0.001	0.002	0.004	0.003	0.002	-0.028***	0.017***
	[0.005]	[0.005]	[0.005]	[0.005]	[0.005]	[0.010]	[0.006]
$WC * OUT^{NAR}$	0.020**	0.020**	0.023**	0.024**	0.021**	0.056***	0.005
	[0.010]	[0.010]	[0.010]	[0.010]	[0.010]	[0.021]	[0.011]
OUT^{SER}	-0.024***	-0.027***	-0.025***	-0.025***	-0.026***	-0.026**	-0.041***
	[0.008]	[0.008]	[0.008]	[0.008]	[0.008]	[0.011]	[0.012]
$WC * OUT^{SER}$	0.042***	0.045***	0.045***	0.045***	0.039**	0.03	0.089***
	[0.016]	[0.016]	[0.016]	[0.016]	[0.016]	[0.022]	[0.023]
ICT		0.017***	0.021***	0.020***	0.016***	0.047***	-0.025***
		[0.003]	[0.003]	[0.003]	[0.003]	[0.005]	[0.005]
$WC * ICT$		-0.011	-0.007	-0.005	-0.001	-0.001	0.019**
		[0.008]	[0.009]	[0.009]	[0.008]	[0.018]	[0.010]
VA			0.048***	0.045***	0.037***	0.081***	0.045***
			[0.007]	[0.007]	[0.007]	[0.024]	[0.008]
$WC * VA$			0.034**	0.037***	0.041***	0.034	0.035**
			[0.014]	[0.014]	[0.014]	[0.058]	[0.014]
$SKILL\_INT$				0.002	0.012***	0.004	-0.002
				[0.002]	[0.002]	[0.003]	[0.003]
$WC * SKILL\_INT$				0.005	0.010**	0.017**	-0.007
				[0.005]	[0.005]	[0.008]	[0.007]
Observations	309343	309343	309343	305781	305781	124689	181092
Number of workers	52840	52840	52840	52362	52362	25483	30994
R-squared	0.21	0.21	0.21	0.212	.	0.162	0.255
F-test	199.075	195.974	193.754	182.341	.	62.496	176.378
χ^2:				9.934[a]			1033[b]
p-value				0.130			1.000

Notes: * significant at 10%; ** significant at 5%; *** significant at 1%. Standard errors (in brackets) are corrected for intragroup correlation. Controls for: workers' age (linear and squared), number of working days (linear and squared), (6) firm size dummies interacted by WC dummy, (20) regional dummies, (13) year dummies interacted by WC dummy, (19) industry dummies interacted by WC dummy. Source: panel ISFOL on INPS data; Giorgio Rampa dataset; OECD STAN database.

[a] The test statistic refers to the test for endogeneity of the outsourcing and ICT and their interactions with the WC dummy. Under the null it is distributed as a $\chi^2_{(6)}$.

[b] The test statistic refers to the test for equality of coefficients across the two subgroups of sectors of columns 6 and 7. Under the null it is distributed as a $\chi^2_{(89)}$.

Table 6: Estimation of equation 5, by worker's status

Dep. Var.: $WAGE$	(1)	(2)	(3)	(4)	(5)	(6)
	All sectors		Traditional sectors		Innovative sectors	
	BC	WC	BC	WC	BC	WC
OUT^{NAR}	0.004	0.024***	-0.030***	0.02	0.018***	0.019**
	[0.005]	[0.008]	[0.010]	[0.019]	[0.006]	[0.009]
OUT^{SER}	-0.023***	0.025*	-0.022**	0.006	-0.041***	0.048**
	[0.008]	[0.014]	[0.011]	[0.019]	[0.012]	[0.020]
ICT	0.019***	0.019**	0.047***	0.051***	-0.026***	-0.002
	[0.003]	[0.008]	[0.005]	[0.018]	[0.005]	[0.009]
VA	0.044***	0.087***	0.094***	0.110**	0.042***	0.085***
	[0.007]	[0.012]	[0.024]	[0.053]	[0.008]	[0.012]
$SKILL\_INT$	0.002	0.008	0.004	0.019**	-0.004	-0.005
	[0.002]	[0.005]	[0.003]	[0.009]	[0.003]	[0.007]
Observations	222570	83211	98826	25863	123744	57348
Number of workers	40308	14279	20930	5461	22360	9845
R-squared	0.12	0.375	0.106	0.301	0.145	0.412
F-test	141.076	171.461	63.517	45.534	118.364	163.89
χ^2:		108475^a		28727^b		41053^c
p-value		0.000		0.000		0.000

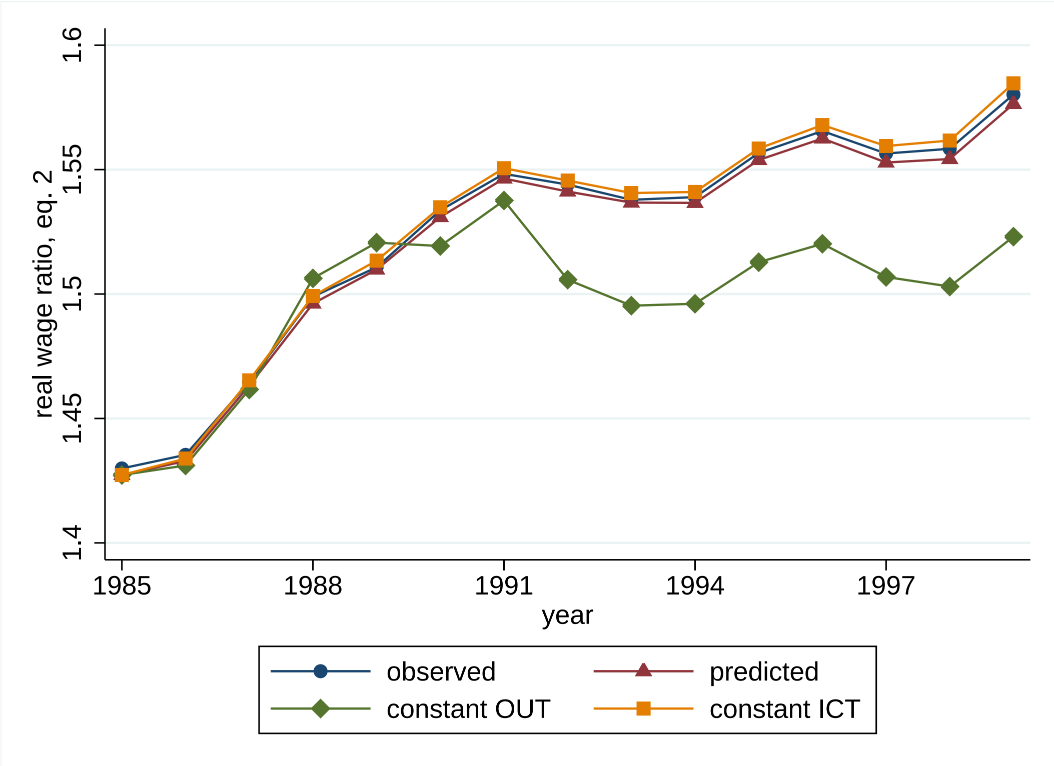
Notes: * significant at 10%; ** significant at 5%; *** significant at 1%. Standard errors (in brackets) are corrected for intragroup correlation. Controls for: workers' age (linear and squared), number of working days (linear and squared), (6) firm size dummies, (20) regional dummies, (13) year dummies, (19) industry dummies. Source: panel ISFOL on INPS data; Giorgio Rampa dataset; OECD STAN database.

[a] The test statistic refers to the test for equality of coefficients across the two subgroups of sectors of columns 1 and 2. Under the null it is distributed as a $\chi^2_{(64)}$.

[b] The test statistic refers to the test for equality of coefficients across the two subgroups of sectors of columns 3 and 4. Under the null it is distributed as a $\chi^2_{(54)}$.

[c] The test statistic refers to the test for equality of coefficients across the two subgroups of sectors of columns 5 and 6. Under the null it is distributed as a $\chi^2_{(55)}$.

Figure 1: Inequality: observed, predicted, at constant 1985 OUT shares and at constant 1985 ICT

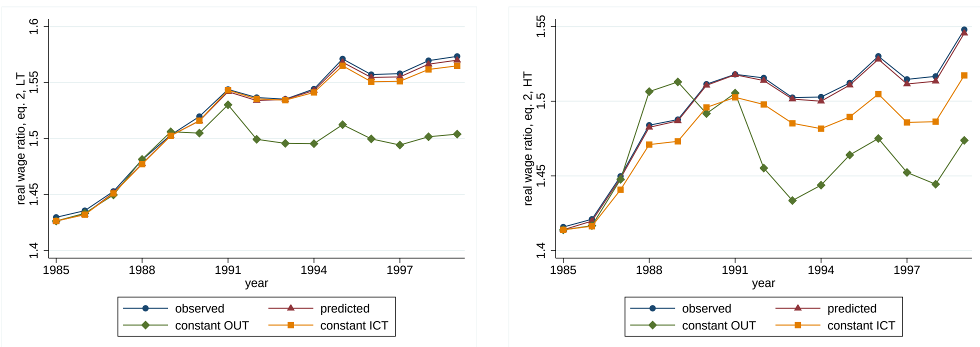


Source: panel ISFOL on INPS data; Giorgio Rampa dataset; OECD STAN database.

Figure 2: Inequality: observed, predicted, at constant 1985 OUT shares and at constant 1985 ICT, by sectors

traditional sectors

innovative sectors



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