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Task changes and labor demand: some new evidence from EU countries.

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Abstract: Drawing on the methodological framework from Acemoglu and Restrepo (2019), this paper intends to provide further evidence of the effects of the latest waves of technological change on the labor market. Focusing on the deceleration of the wage bill and the reduction of the labor share that took place in the main European countries in recent decades, along with the introduction of automation technologies and new jobs-tasks, the paper aims at investigating the shifts occurred in the major components of the labor demand. Especially, it targets the role of the task content of production, in an effort to highlight technology-related displacing and reinstating forces that contributed to such changes. Using sectoral data from the EU-KLEMS database, we apply the A-R decomposition methodology to the case of Italy, Germany, France and Spain, in the 47-years' span of time running from 1970 to 2017. Preliminary results say that the net effect of the changes occurred in the task content of production greatly differ from case to case, according also to specific national dynamics in terms of production structure and welfare state.

Keywords: labor share, task changes, automation, inequality, Europe.

Acknowledgements

In this paper we present some very preliminary results of a work that is developing within a joint research project between INAPP and SEP-LUISS, investigating the effects of automation on occupation and labor market dynamics. At this intermediate stage of our work we could benefit from helpful comments and suggestions from Andrea Ciarini and Marcello Messori.

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Introduction.

This article aims at contributing to the debate on the effects of automation on occupation. Investigating the changes occurred in the wage bill, value added and labor share within main EU countries, it intends to disentangle the labor market dynamics over recent decades, as characterized by a significant wave of automation.

Especially, this study targets the role of the task content of production, in an effort to highlight technology-related displacing and reinstating forces that contributed to the changes in labor demand. Concerning the task-based approach, the Skill Biased Technological Change (SBTC) has been the first inherent theory conceived, starting with the observation of the occupations polarisation[1]. That basic model has been modified and revised by the Routine Biased Technological Change (RBTC, firstly specified by Autor, Levy and Murnane in 2003). According to this view, the single task is what matters. Performed tasks become increasingly routinized among medium-skilled workers, giving way to standardization of their work and easier replacement by new technologies (Autor et al., 2013).

This strand of technology-related literature has evolved in parallel with the one focusing on the impact of globalization on tasks. As a matter of fact, tasks' offshoring has become a prominent feature of globalization, producing consequences like changes in the composition of onshore tasks. Becker, Ekholm, and Muendler (2013) found a significant association of these factors with non-routine tasks. Also, highly qualified occupations or managing positions can be delocalized too. This means that firms can choose to access foreign job markets to hire more qualified workers without paying any additional transaction costs.

Within this theoretical framework, a relevant contribution to the literature came in 2019 from Acemoglu and Restrepo (for brevity, A-R hereafter). Following their previous works (2011, 2018, 2019), the authors focused on the components responsible for the change in wage bill in the US economy. Based on a theoretical model that explicitly allows for modifications of task contents of production, they formulated a decomposition technique to account for the effects induced in the economy-wide wage bill by changes in: productivity, sector composition, factor substitution and task content, being each of them susceptible to be affected by automation and technological change. What they posit is that, the change in task content is the net result of two opposing forces. A *displacement* effect, due to the automation-induced rise of capital against labor in a range of tasks; and a *reinstatement* effect, connected to technologies that creates new labor-intensive tasks. While historically, in all former technological waves the positive forces (reinstatement) have offset the negative ones (displacement), at least in the medium- and long-run horizon, this may not be necessarily the case if the reinstatement forces are not strong enough to compensate the displacement of labor in the automated tasks (not only quantitatively, but also qualitatively in terms of "good" new occupations). Particularly, A-R find that this is what happened in the United States since the end of the 80s when, contrary to the developments of the preceding (post-war) period, both the wage bill and the wage share of American workers were negatively affected by a contraction in the production task-content. This was due to a deceleration in the introduction of technologies reinstating labor, and a concurrent acceleration of technologies displacing it.

Looking at the factor distribution of total incomes, a reduction of the labor share appears evident in the EU as well. Similar studies on European data, like the one by Chiacchio et al. (2018), found a predominant displacement effect at the expenses of labor. The use of robots can indeed induce positive outcomes and increase productivity, but data on the main EU countries[2] showed also how employment levels –especially those of young and medium skilled workers– have been negatively affected by the introduction of automation in the production process.

Especially from the 80s on, this has gone hand in hand with structural changes, like the service industry increasing its weight against manufacturing's. In addition, many new tasks concern new services

[1] For a review see e.g. Eurofound (2016).

[2] Germany, Italy, Sweden, Finland, Spain and France, accounting together for 85% of the industrial robots market.

and digital economy, and are conveyed by online platforms, giving birth to several new occupations and atypical contracts. On the one hand, these provide more flexibility to the benefit of the worker too, but on the other hand they are not guaranteed as traditional forms of employment and are not covered by national welfare insurance. After the 2008 crisis in the EU, the employment rate has raised again, but many new jobs have been created greatly in this way: by part-time or new kind of contracts (and this happened equally among workers' distribution) (Eurofound, 2017)[3] . Different alternative scenarios can be thought of. For instance, either new investments in capital make workers more productive and lead to a general improvement; or technology replaces workers -performing the same tasks more efficiently- and inequalities between capital owners and workers increase (DG EMPL, 2018).

This article illustrates the steps followed to measure changes in jobs tasks and labor demand as they happened following the capital substitution for labor in recent decades in Germany, Italy, France and Spain. Applying the decomposition approach presented by A-R (2019), the changes in labor demand have been split into different productivity and labor components, over the span of time from 1970 to 2017. Preliminary results show a generally decreased level of the labor share in the considered span of time, with some national dynamics in terms of welfare regimes and production structure specificities.

Tasks first: the Acemoglu-Restrepo framework.

The impact of technological change, namely *automation*, on labor demand, and so especially on wages and employment, is a widely debated issue in the socioeconomic literature. Being it a source of controversy, allows some to optimistically consider the current automation wave alike all the previous technological advancements, which ultimately increased labor demand, wages and employment levels (Naone 2009). While others, see the current phase of technological change as a different process, potentially leading to widespread displacement of human labor, and tracing some specific traits of this wave of automation (e.g. Korinek and Stiglitz (2019) on artificial intelligence). It has also been noted how, based on these specific traits, the recent surge cannot be directly compared to the previous industrial revolutions of 18th and 19th centuries: AI is impacting our society ten times faster and at significantly higher scale (McKinsey Global Institute, 2015). This meaning that past examples of major technological advancements may not be able to properly capture the dynamics of current automation.

In order to account for all the forces at play in this complex process, it has to be first of all clarified how automation should be conceptualized. Traditional economic modelling appear insufficient and inappropriately leading to unambiguous optimism..

New modelling by A-R (e.g. 2018a, 2018b, 2019), allows for both good and bad results, focusing on tasks first. Production requires the completion of a range of tasks, each of them can be performed by human labor, (L), and capital, (K) in terms of either machinery or software. The allocation of tasks to factors -L and K- is what determines the *task content of production*.

The introduction of new technologies in this process can increase productivity of both capital and labor, based on tasks they currently perform. Automation impacts allocation of tasks to production factors, enabling capital to be substitute for labor in a range of tasks. As capital takes over tasks originally performed by labor, the effect will be a displacement of labor. As a result, labor share reduces as wages grow slower than productivity. On the other side, automation can allow for a better use of inputs, increasing productivity and so raising labor demand in non-automated tasks thanks to it. The net impact on labor demand generated by

[3] A categorization of these occupations is provided by: Eurofound (2015). New forms of employment, Publications Office of the European Union, Luxembourg.).
Eurofound (2016), What do Europeans do at work? A task-based analysis: European Jobs Monitor 2016, Publications Office of the European Union, Luxembourg.
Eurofound (2017:1), 6th European Working Conditions Way - 2017 Update.
Eurofound (2017:2), Non-standard forms of employment: Recent trends and future prospects, Background paper for Estonian Presidency Conference 'Future of Work: Making It e-Easy', 13–14 September 2017.

automation will depend on how its productivity and displacement effects weight against each other eventually.

In addition, new technologies can originate new tasks, in which labor may have a comparative advantage. These new tasks can generate also positive productivity effects, and reinstate labor in a broader range of tasks, increasing labor share and labor demand.

In order to analyze the changes occurred in the labor demand, A-R (2019) focus on the wage bill, identified as the product of value added per labor share:

$$wage\ bill \equiv value\ added\ x\ labor\ share \tag{1}$$

Investigating these variations, they focus on technological change identifying three different classes technological change susceptible to affect the wage bill. These are:

- **Automation**. It originates, thanks to the induced higher productivity, an increase in value added, but at the same time also a *displacement* effect of labor: it enlarges the general size of the pie (productivity effect), but labor comes to represent a smaller slice of it (falling labor share). Hence the wage bill can contract following automation, if the fall of labor share outpaces the productivity increase. According to the authors this is the case of the "so-so technologies", those that provide a small productivity improvements in the face of an ample displacement effects.
- **Introduction of new job-tasks**. This also induces a positive productivity effect, but at the same time a labor-*reinstatement* one too, thanks to new tasks that increase the share of labor over capital: the wage bill is unambiguously increased by the creation of new (labor intensive) tasks, as it is raised through both the productivity and the change-in-task-content channels .
- **Factor augmenting technologies**. Here as well there is an increase in productivity leading to higher value added as a result of their introduction. The impact on the labor share depends on the *substitution* between production factors (capital and labor) that is caused by this kind of technological change. Direction of change in the labor share crucially depends on whether the elasticity of substitution between the production inputs is larger or smaller than 1. Particularly, being these technology improvements irrespective of the specific production tasks, but homogeneously referred to all of the tasks performed by means of the technology-augmented production factor, they generate changes in the relative (effective) remuneration of production factors and a substitution effect between the augmented and the non-augmented production factor. As an example, if technology augments labor productivity across all tasks this production factor performs, this reduces its effective remuneration (i.e. efficiency-adjusted remuneration) relative to capital. Whether this reduction leads to either a rise or a fall of the labor share depends on the elasticity of substitution between factors. If the latter is lower than one, the reduction of effective wage (relative to capital remuneration) caused by the labor augmenting technology, is accompanied by a less than proportional substitution of labor for capital- and a subsequent fall of labor share.

These technology-induced effects on the wage bill are detectable at sector level. When considering the total economy as whole, a sector *composition* effect has to be added to those highlighted above. In this view, the changes in the aggregated wage bill will be given by:

$$\textit{wage-bill change} = productivity\ effect + composition\ effect + substitution\ effect + change\ in\ task\ content\ effect \tag{2}$$

Assuming perfect competition in the product and factor markets as A-R do, the "forces" on the right-hand side of the equation would detect exhaustively all the technology-induced effects determining changes in the wage bill. Hence, given this assumption, once identified the *productivity*, *composition* and *substitution* effects one can derive the change in task content effect as a residual. Particularly, the latter is obtained at sector level, as the (fixed-sector composition) labor share variation minus the substitution effect. These sectoral changes in task content are then aggregated with appropriate weights to get the economy-wide *change in task content* effect indicated in the former equation.

Based on the sign of the result of the obtained change in task content, there will be a *displacement* effect if negative, or a *reinstatement* effect if positive. The underlying assumption made within this methodological framework, is that an industry can engage in either automation or the creation of new job-tasks, but not both activities at the same time (Acemoglu, Restrepo, 2019).

Methodology: the Acemoglu-Restrepo decomposition.

The observed changes can therefore be decomposed in the variations occurred in three separate dimensions, so to say the total economic output, the sectoral share in value added and the sectoral labor share. These are identified with the specific effects mentioned so far, which are operationalized by means of the relations identified by the following equation:

$$\Delta \ln(WL) = \Delta lnY \ + \ \sum_i \frac{S_i^L}{S^L}\Delta\chi_i \ + \ \sum_i \ell_i(1-\sigma)(1-S_i^L)(\Delta ln\, W_i/A_i^L - \Delta ln\, R_i/A_i^K) \ + \ \sum_i \ell_i \frac{1-S_i^L}{1-\Gamma_i}\Delta ln\Gamma_i \qquad \textbf{(3)}$$

Where the term on the left-hand side represents the changes in labor demand and WL stands for the economy-wide wage bill. While those on the right highlight four effects in which the wage-bill change can be decomposed, and they refer to productivity, composition, change in task content and substitution components. More in detail, these components can be made explicit as follows:

$Productivity\ effect_{t_0,t} = \ln\left(\frac{Y_t}{N_t}\right) - \ln\left(\frac{Y_0}{N_0}\right)$, to account for the variation in GDP per capita in the period between *0* and *t*, where *Y* denotes the real total value added in the economy;

$Composition\ effect_{t_0,t} = \ln\left(\sum_i \chi_{i,t} S_{i,t}^L\right) - \ln\left(\sum_i \chi_{i,t_0} S_{i,t}^L\right)$, to consider the reallocations within the total production mix, measured by the changes in value added produced by each economic sector relative to total value added; where $\chi_{i,t}$ denotes the share of sector *i*'s in total value added and S_i^L that in total labor.

$Substitution\ effect_{t_0,t} = \sum_i \ell_{i,t_0} Substitution\ effect_{i,t_0,t}$, to measure the amount of labor substituted by capital following changes in relative effective remuneration of production factors. It is given by the aggregation of its occurrence in every single sector *i*:

$$Substitution\ effect_{i,t_0,t} = (1-\sigma)(1-S_{i,t_0}^L)\left(ln\frac{W_{i,t}}{W_{i,t_0}} - ln\frac{R_{i,t}}{R_{i,t_0}} - g_{i,t_0,t}^A\right)$$

where σ= the elasticity of substitution between capital and labor; W_i and R_i = factor prices, for labor and capital; A_i^L and A_i^K= factor augmenting technologies, which have been operationalised by g_i^A= growth rate of A_i^L compared to that of A_i^K.

$Change\ in\ task\ content_{t_0,t} = \sum_i \ell_{i,t_0} Change\ in\ task\ content_{i,t_0,t}$, to measures the (net) influence on displacement and reinstatement effects in the labor share. It can be estimated in each sector i by $\frac{1-S_i^L}{1-\Gamma_i}\Delta ln\Gamma_i$ where Γ_i represents the task content of each sector *i*.

In a perfect competition environment as the one depicted by Acemoglu and Restrepo, the *substitution* and *change in the task content* effects represent two (exhaustive) components into which the *labor share* "effect" can be divided:

$Labour\ share\ "effect"_{t_0,t} = \ln\left(\sum_i \chi_{i,t_0} S_{i,t}^L\right) - \ln\left(\sum_i \chi_{i,t_0} S_{i,t_0}^L\right)$, to consider the modifications to the total employment structure, measured by the changes in the labor share of each economic sector with fixed value-added weights. That is why the change in task content effect can be here derived also as follows:

$$Change\ in\ task\ content_{i,t_0,t} = \ln S_{i,t}^L - \ln S_{i,t_0}^L - (1-\sigma)(1-S_i^L)\left(ln\frac{W_{i,t}}{W_{i,t_0}} - ln\frac{R_{i,t}}{R_{i,t_0}} - g_{i,t_0,t}^A\right)$$

The economy-wide aggregation of sectoral effects is weighted in both cases by means of the share of the wage bill generated in sector *i*: $\ell_i = {}^{W_i L_i}/_{WL}$

In our application of the A-R framework, we abandon the assumption of perfect competition in the product market though, and allow for mark-ups charged by producers on marginal costs. This leads to a relevant modification in the decomposition model. Under perfect competition, the observed economy-wide (fixed-sector weights) labor share can be assumed to be exhaustively decomposable in a *substitution* and *change in task content* effects as follows:

$$LS_{perf} = (W \cdot N)/(P \cdot Y) = \left({}^{W}/_{P}\right) \cdot \left({}^{N}/_{Y}\right) = substitution\ change\ in\ task\ content \quad \textbf{(4)}$$

Under imperfect competition in the product market, a markup wedge has to be introduced in the decomposition of the observed (fixed-sector weights) labor share as follows:

$$LS_{imperf} = \left({}^{1}/_{m}\right) \times (W \cdot N)/\left({}^{W}/_{P}\right) \cdot \left({}^{N}/_{Y}\right) = 1/markup \times substitution \times change\ in\ task\ content \quad \textbf{(4a)}$$

This implies that, to correctly identify the *change in task content* effect (and the underlying displacement and reinstatement effects), the observed labor share has to be purged of any markup change. In other words, this is relevant as under (product-market) imperfect competition, a contraction of the (fixed-sector weights) labor share may be caused by markup increases, rather than by negative changes in task content (displacement larger than reinstatement) and vice versa.

Finally, *displacement* and *reinstatement* effects were calculated by means of a 5-years moving average of the sectoral *change in task content* effect:

$$Displacement_{t-1,t} = \sum_i \ell_{i,t_0} min\left\{0, \tfrac{1}{5}\textstyle\sum_{\tau=t-2}^{t+2} Change\ in\ task\ content_{i,\tau-1,\tau}\right\}$$

$$Reinstatement_{t-1,t} = \sum_i \ell_{i,t_0} max\left\{0, \tfrac{1}{5}\textstyle\sum_{\tau=t-2}^{t+2} Change\ in\ task\ content_{i,\tau-1,\tau}\right\}$$

In this work, we apply the A-R framework to study the wage-bill development in the four major Eurozone countries (Germany, France, Italy and Spain) over the time-span 1970-2017.

Data.

Using sectoral data, we applied the A-R decomposition methodology to the case of Italy, Germany, France and Spain, in the 47-years' span of time running from 1970 to 2017. Total economy has been considered either as a whole, or disaggregated in subsections such as market economy, manufacturing and services. Main results presented in this paper refer to the market economy decomposition.

Main source of data for this analysis has been the EU KLEMS database. It is a comprehensive source of harmonized measures -on economic growth, productivity, employment, capital formation and technological change at the industry level- that covers all the European Union member states, along with Japan and the US.

To get the wider period of time possible, we combined the 2009 release –as updated in 2011- together with the latest version published in November 2019. Considered variables in the 1970-2017 period present a break in time series in 1995 due to the change in the NACE revision/SEC 2010 change.

The total economy value added has been measured by gross value added at current basic prices (in million euros). It has been normalised using population data from the AMECO database provided by DG ECOFIN. Total population has been considered first, along with the number of persons in labor force age in a second stage of analysis. Differences in the normalisation population were not significant.

For the wage bill we adopted compensation of employed persons at current basic prices (in million euros). Labor share has been calculated based on these two variables, as drawn upon equation (1). Both economy-wide value added and compensation of employees data have been deflated, by means of the gross value added price indices available in EU KLEMS databases.

As for the elasticity of substitution between capital and labor, we considered estimates available in the empirical literature. These vary substantially according to methods and periods of estimation (Rowthorn 1999, Muck 2017) . A relevant degree of heterogeneity across European countries is reported for the most recent period by Villacorta (2020). Even with the uncertainty of estimation, available estimates for the considered countries point to a lower-than-1 elasticity of substitution (with some exceptions for Spain). As a baseline, we adopted an elasticity of substitution of 0.8 for all countries, across the whole period. This roughly corresponds to the average value in the Villacorta study for the four EU countries we consider (with Italy below and Spain above it). This is also the value considered by A-R for the US case.

Effective factor prices for labor and capital have been derived from the quantity measures available in the EU KLEMS database. A price index for labor (Wi) accounting for the ratio between worker compensation and full-time equivalent workers on one side; a price index for capital (Ri) considering the ratio between capital income and the quantity of capital used on the other side.

As for the average labor productivity, measuring the labor augmenting technology effect compared to that of capital, we considered the (log) growth rate of value added per hour worked, available in EUKLEMS.

Finally, based on the literature (De Loecker, Eechout, 2017) and on National accounts practices, drawing on EUKLEMS data, we estimated a proxy for the price mark up as follows:

$$MU = Gross\ Output/(Labor\ compensation\ \times Intermediate\ Inputs)$$

All variables were taken at current prices in million euros, and considered in the estimations as logarithmic variation of each time period over the base year.

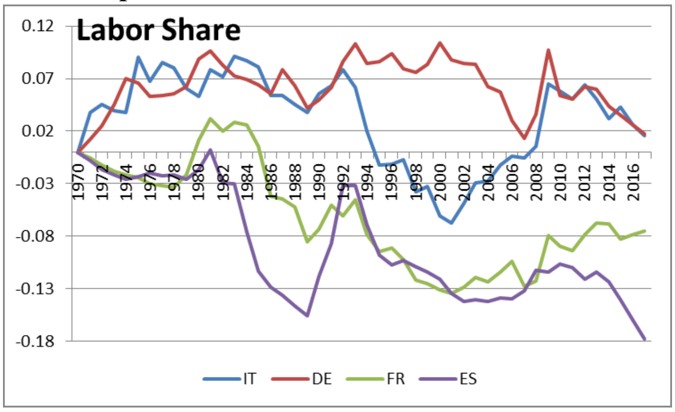
Preliminary results.

Preliminary results say that the net effect of the changes occurred in the task content of production greatly differ from case to case. As an example, Germany shows a positive one throughout the considered period, while Italy and France reveal a trend reversal beginning in the 90s and resulting in a persistent predominance of displacement over reinstatement effects. Spain dynamics remain somehow far from those of the other considered countries, probably due to national specificities in terms of labor market policies.

Main results presented in this paper refer to the Market Economy aggregate, over the time period 1990-2017. First of all, obtained estimates tell us of a progressive growth of wage bill and productivity, widespread in all considered countries and especially during the first decades analyzed. From the 90s these trends slow down and ultimately slightly fall following the 2008 economic crisis.

Labor share trends, instead, tell quite country-specific stories, highly influenced by national social welfare policies and factor prices fluctuations- with a far better performance of Germany compared to the others. Graph 1. depicts these trends in the four considered countries, from 1970 to 2017. Still with some national-level specificities that leave out Germany and show an even previously negative trend in Spain, it is recognizable a common fall starting in early 90s.

Graph 1. Labor share, 4 countries, 1970-2017

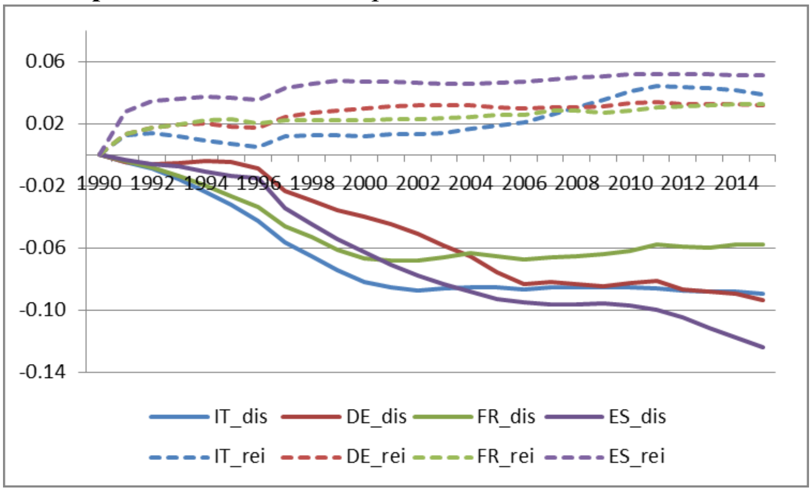


Breaking the labor share down into *substitution* and *change in task-content* effects, allowed to trace it back to the two separate components per each country. In the case of Italy, for example, the effect identifying the substitution between capital and labor assumes positive values in the first decades, to become negative between beginning of the 90s and end of 00s. In the case of Spain, instead, changes in the task-content of production appear as the force leading the entire trend down over the 80s. Anyway, the latter seems to be the main driver of the observed variations in the wage bill for all considered countries. Decomposing it into *displacement* and *reinstatement* effects may help better understand its dynamics over time.

_Country comparisons

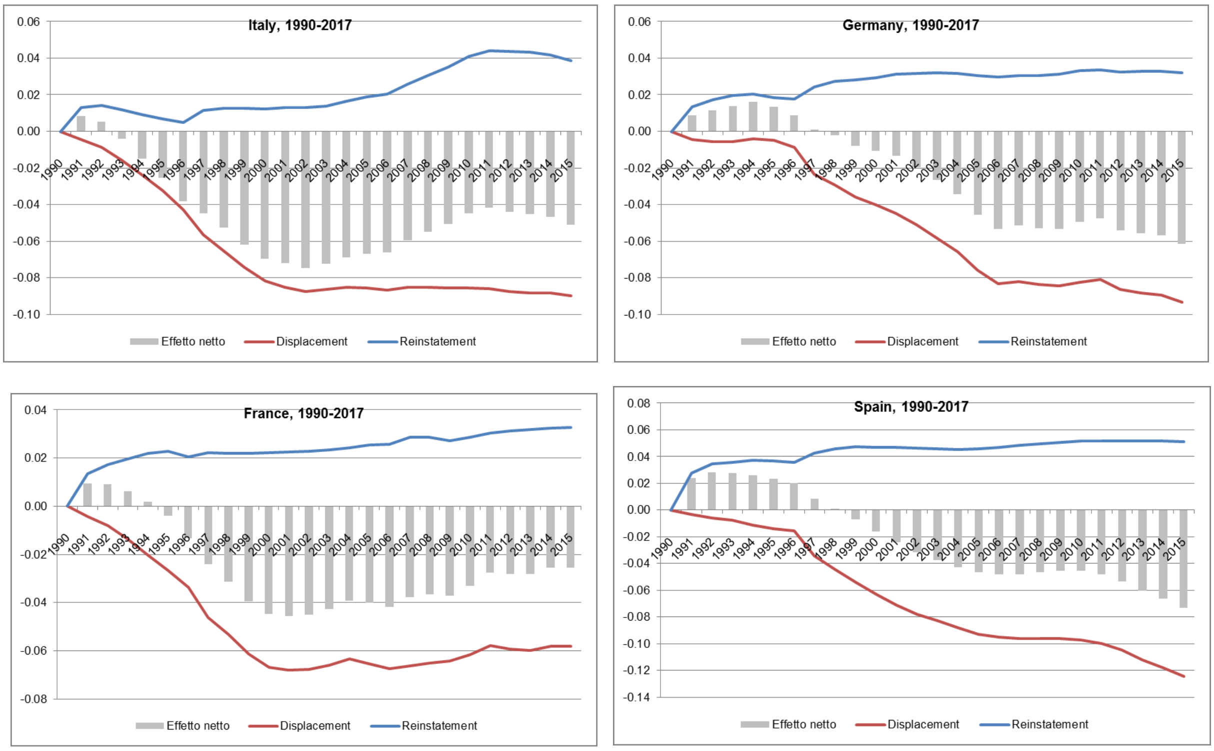
To find out more, results can be read on a country-level basis, considering the Market Economy as a whole and looking at the trends of estimated effects throughout the selected time period. Graph 1. shows Germany, Italy, France and Spain together. Dashed lines represent the *reinstatement* effects, and so are located into the positive half of the plan, while the solid line represent the *displacement* effects, located in the opposite part of the plan. If in the 1970-1990 period seemed to be more homogeneity between Germany and Italy, while France and Spain were more far below, in the 1990-2017 period showed in Graph 2. some similarity among reinstatement trends can be seen - even if their magnitude is still country-specific. From the mid-90s, a common worsening in terms of displacements also appears clearly.

Graph 2. Reinstatement/displacement 4 countries, 1990-2017



Spain shows a higher level, but in both dimensions. That is why it is important to consider the *net effect*, given by the sum of reinstatement and displacement levels, as shown in the following Graphs 3-6.

Graph 3-6. Net effect, 4 countries, 1990-2017

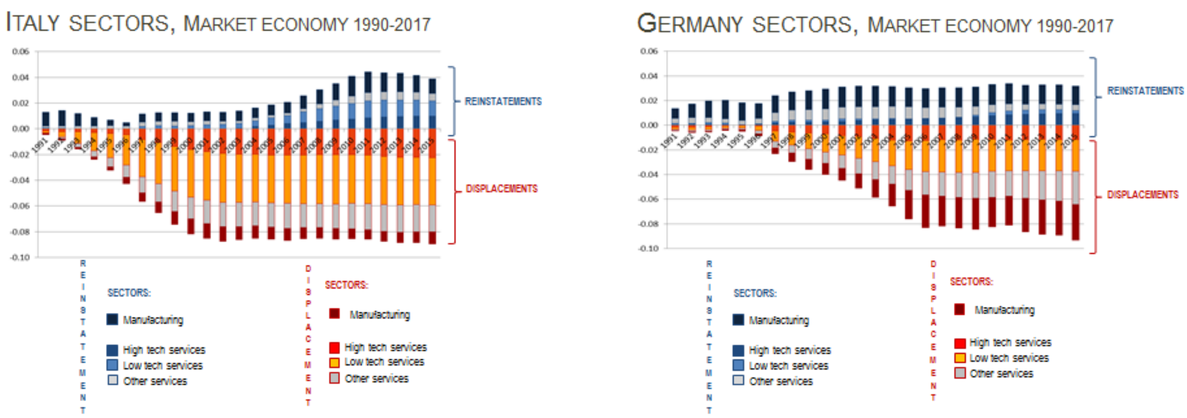


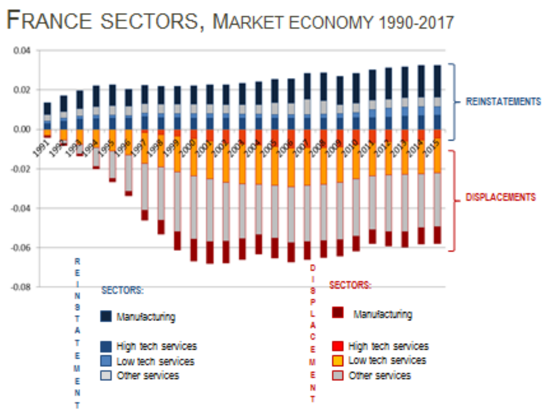
Beyond the trends depicted by the blue reinstatement lines and the red displacement ones, grey columns more clearly tell the story of each country in the considered years.

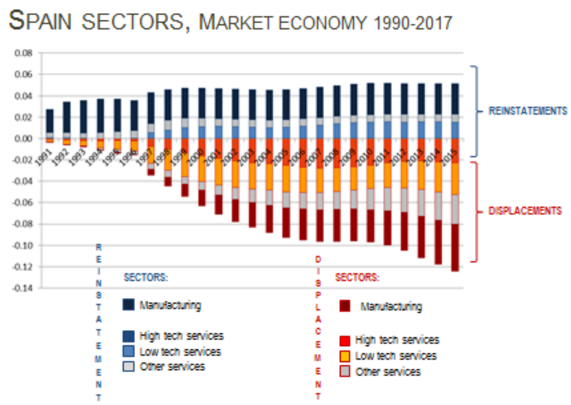
_Sectors comparisons

A second interpretation of our results compares the sectoral composition of the highlighted effects, within each national economy. This allows to better understand the losers and winners in the process of automation, according to the country-specific production structure.

Graph 7-10. Sectoral contributions to displacement/reinstatement, 4 countries, 1990-2017







As shown in Graphs 7-10, different sectoral dynamics can move within the same level or trend, of either displacement or reinstatement. Each country shows a specific sectoral contribution to both of these effects, which can tell us more about how the automation process is impacting the local labor market and demand.

These charts shows composition shares of single sectors to each effect. Blue and red segments represent either reinstatements or displacements respectively. Darker sections identify manufacturing sectors; lighter colors represent services –divided into high and low, based on their share of total value added-; finally, in grey are all the remaining sectors (i.e. agriculture, mining, energy sector, waste management and constructions).

Conclusions.

As showed, the net effect of the changes occurred in the task content of production greatly differ from case to case. The magnitude of these possible effects, or the combination of them, really much depends on the nature of the job-tasks to be carried out by workers; on the kind of technologies introduced; on the relationship between capital and labor, namely their elasticity of substitution and their factor prices; besides the innovation capacity of firms and workers; and above all the policy choices and welfare systems.

These are some of the reasons why the decomposition approach applied to four EU countries and presented in this article represents just the first step of this research work.

Further steps and in-progress research include the study of the correlation of the obtained results to country specific variables, to shed some light on the national dynamics in place over the considered decades.

Obtained estimates are being further investigated to explore how changes in the task content of production evolved over time and what they correlates to. Considered dimensions of analysis include: automatable employment shares and use of robots at firms level; new jobs tasks and occupations as opposed to routine jobs; globalization and shares of intermediate goods in international trade. Finally, they may allow also to explain part of the variation in the national levels of output, total factor productivity and skilled workers shares.

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