EUROPEAN CENTRAL BANK
EUROSYSTEM

WAGE DYNAMICS NETWORK

WORKING PAPER SERIES
NO 1199 / MAY 2010

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by Rebekka Christopoulou[2],
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and Ana Lamo[4]

In 2010 all ECB publications feature a motif taken from the €500 banknote.

1 This paper is part of the Wage Dynamic Network (WDN) research. We are very grateful to David Autor, Christian Dustman, Hervé Le Bihan, Thomas Lemieux, Frank Smets, participants at the June 2008 WDN Conference and the 2009 AEA meetings and an anonymous referee for their useful comments and suggestions We also thank our WDN colleagues for their support and cooperation. Support from DG-Statistic (ECB) and Frank Smets was essential to gain access to five of the SES data sets used in the paper. We are grateful to Andrew McCallum for initial help with the data. We would also like to thank Eurostat for the hospitality and the National Statistical Institutes of each one of the countries studied in this paper for granting us with the SES data access and assisting with clarifications. Opinions expressed in this article do not necessarily reflect the views of the Banco de España. Errors and omissions are responsibility of the authors.

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Wage Dynamics Network

This paper contains research conducted within the Wage Dynamics Network (WDN). The WDN is a research network consisting of economists from the European Central Bank (ECB) and the national central banks (NCBs) of the EU countries. The WDN aims at studying in depth the features and sources of wage and labour cost dynamics and their implications for monetary policy. The specific objectives of the network are: i) identifying the sources and features of wage and labour cost dynamics that are most relevant for monetary policy and ii) clarifying the relationship between wages, labour costs and prices both at the firm and macro-economic level.

The WDN is chaired by Frank Smets (ECB). Giuseppe Bertola (Università di Torino) and Julián Messina (World Bank and University of Girona) act as external consultants and Ana Lamo (ECB) as Secretary.

The refereeing process of this paper has been co-ordinated by a team composed of Gabriel Fagan (ECB, chairperson), Philip Vermeulen (ECB), Giuseppe Bertola, Julián Messina, Jan Babecký (CNB), Hervé Le Bihan (Banque de France) and Thomas Mathä (Banque centrale du Luxembourg).

The paper is released in order to make the results of WDN research generally available, in preliminary form, to encourage comments and suggestions prior to final publication. The views expressed in the paper are the author's own and do not necessarily reflect those of the ESCB.

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ISSN 1725-2806 (online)

CONTENTS

Abstract

We study changes in the wage structures in nine EU countries over 1995-2002 and the role of demand, supply and institutional developments in shaping these changes. Using comparable cross-country microeconomic data, we compute for each country and at each decile of the wage distribution, the part of the observed wage change that is due to changes in the composition of workers, employers, and jobs' characteristics, and the part due to changes in the returns to these characteristics. We find that composition effects derived from changes in age, gender or education of the labour force, largely exogenous to economic developments, had a minor contribution to the observed wage dynamics. In contrast, return and composition effects from characteristics likely driven by economic developments are found most relevant to explain the observed changes. We relate wages and their various components with macroeconomic and institutional trends and find that technology and globalisation are associated with wage increases; migration is associated with declines in wages; whereas the effect of labour market institutions has been mixed.

Keywords: *Wage Structure, Quantile Regressions*.
JEL Codes: J31

Executive summary

In this paper we study changes in the wage structure of nine EU countries (Austria, Belgium, Germany, Greece, Hungary, Ireland, Italy, the Netherlands, and Spain) over the period 1995-2002 using micro data on wages and on workers and jobs characteristics that are comparable across countries.

Observed changes in real wages during the sample period have been mostly positive along the whole range of wage levels, but both the magnitude and shape of the changes observed differ substantially across countries. Observed real wages in the Netherlands, Germany, and Greece trend upwards along the wage distribution; i.e. wage increases are higher for higher paid jobs. The consequent increase in wage inequality is of similar or larger magnitude to the increase in wage inequality observed in the US over the same period. A widening of the observed wage distribution is also observed in Belgium and Italy, but is less pronounced. In contrast, the wage distribution in Hungary, Ireland, and to a lesser extent in Spain has become more compressed. Finally, in Austria wage changes are very small and have no noticeable effect on wage inequality.

We compute for each country and at each decile of the wage distribution, the part of the observed wage change that is due to changes in the composition of workers, employers, and jobs' characteristics, and the part due to changes in the returns to these characteristics. We find that it is the contribution of market forces that has been driving wage changes. Indeed, mechanical compositional changes as those derived from changes in age, gender or education of the labour force had a minor contribution to the observed wage dynamics. In contrast, return and composition effects from characteristics likely driven by economic developments are found most relevant to explain the observed changes.

The role of economic developments is confirmed when we examine the responsiveness of changes in the wage structure in EU countries to macroeconomic trends and institutional features. Among our most interesting results we find that observed changes in technology are positively associated with wage increases, with the effect being stronger for very high and very low paid jobs. Globalisation is also associated with wage increases, but less so for the lowest wages. Finally, migration is associated with declines in wages; whereas the effect of labour market institutions has been mixed.

1. Introduction

The literature on the determinants of relative wages, wage inequality and, in general, the wage structure has been developing extensively over the last two decades. A significant portion of this research has focused on the US and the UK, providing ample evidence that their wage distribution has been widening since the 1980s. However, there is still an open debate about the nature, causes and timing of this trend. Some authors claim that the widening of the US wage distribution was a one-time event associated with changes in labour market institutions (de-unionisation, changes in the minimum wages) and mechanical compositional effects (exogenous changes in labour force features). Others claim that it has continued throughout the 1990s and 2000s and was due to skill-biased technological change.[1] Several alternative hypotheses have been also tested; among them, the impact of trade integration and the occupational bias in technological change reducing the demand for "routine tasks".[2]

The experience of continental Europe has long been considered milder.[3] The prevalent explanation for this has been the lack of wage flexibility - largely seen as a consequence of strict labour market regulation – that has resulted in wage compression. This is, in turn, responsible for the increase in unemployment among unskilled workers in the 1980s and early 1990s (Krugman, 1994). However, more recently some studies have shown changes in the wage structure of European countries that seem similar to those observed in the US but have occurred a few years later. For example, the 2007 OECD Employment Outlook (OECD, 2007) shows a widening of the wage distribution from 1994 to 2005 in the vast majority of OECD countries (with the exception of Ireland, Japan and Spain). Similarly, Koeniger, Leonardi and Nunziata (2007) document increasing inequality for a number of OECD countries using macro data. Moreover, some country-specific European studies using micro data have also documented sizeable changes in the wage structure (see, for example, Machado and Mata (2005) for Portugal, and Schönberg, Dustmann and Ludsteck (2009) for Germany).

[1] For evidence on the first view see DiNardo et al. (1996) and Lemieux (2006a, 2006b); for evidence on the second, see Autor, Katz and Kearney (2008) and Machin and van Reenen (1998). Comprehensive surveys are Katz and Autor (1999) and Acemoglu (2002).

[2] Studies claiming that there has been a change in the relative demand for skills originated in the technology are, for instance, Bound and Johnson (1992), Krueger (1993), Berman, Bound, and Griliches (1994), Autor, Katz, and Krueger (1998), Machin and van Reenen (1998) and Chennells and van Reenen (1999). On the impact of institutions, see DiNardo et al. (1996); on trade integration and the wage structure, see Lawrence and Slaughter (1993) and Leamer (2000). On the "routinization" hypothesis, see Autor, Levy and Murnane (2003) and Goos and Manning (2007). Regarding wage dispersion within firms, see Lazear and Shaw (2009).

[3] Table A1 reports some raw statistics of wage inequality in the countries of our sample.

To this date, however, there has been little systematic accounting for cross-country differences in wage dynamics in EU countries over the past decade.[4] This is due to one main difficulty: the lack of comparable microeconomic data that could allow the computation of comparable wage measures net of changes in labour force characteristics. Existing cross-country studies that utilize micro data usually rely on imperfectly comparable indicators of wage inequality or dispersion obtained from various sources. On the other hand, cross-country comparisons in the aforementioned macro-level studies are contaminated by employment compositional effects. Therefore, any observation of how the wage structure has been adjusting in response to different macroeconomic shocks and institutional changes is blurred.

In this paper, we avoid these limitations, using a data set that provides rich information on wages, worker and job characteristics for nine countries with very different economies (Austria, Belgium, Germany, Greece, Hungary, Italy, Ireland, the Netherlands and Spain). The period of data availability (1995-2002) for these countries is characterized by a variety of economic, demographic, and institutional developments. We analyse wage changes over this period and by individual country using Mincerian (quantile) wage regressions and the Machado and Mata (2005) procedure. At each decile of the wage distribution and for each observable worker and job characteristic, we compute the composition and price components of wage changes and interpret them in relation to concurrent market and non-market developments.

Our exercise is different from those typically performed in the wage inequality literature in that they focus on personal characteristics whereas we also use information on jobs. The return effects of job characteristics are informative because they represent the "price" of a "specific job task". Thus, the return effects of both worker and job characteristics should provide a better indication of the prevalence of relative wage rigidities than the overall wage change or price effects of personal characteristics alone. The interpretation of composition effects of job characteristics is less straightforward. While personal characteristics such as education, gender and age are usually taken as independent of market forces, the composition effects of job characteristics can not always be assumed to be so, since many of them include quantity-side adjustments to demand and supply

[4]Recent work on wage differentials for European countries includes several papers produced within the Pay Inequality and Economic Performance project (PIEP) which used 1995 data (see Marsden, 2005). Currently, several studies within the Wage Dynamic Network (WDN) analyse relative wages across industries using 1995 and 2002 data. Du Caju et al (2010) summarise the WDN evidence on industry wage differentials for a sample of 8 EU countries. In addition, a number of detailed country specific projects that look at changes in the wage distribution along deciles are ongoing work within the WDN (see Pointner and Stiglbauer, 2008, for Austria, Dybczak and Galuscak, 2008 for Czech Republic, and Christopoulou and Kosma, 2009 for Greece).

shifts (e.g. changes in sectoral composition, firm size, etc). However, because we conduct the decomposition analysis for each covariate separately, we are able to separate any composition effects that may be responsive to market forces from those that are largely predetermined. Thus, we analyse two different measures of market-responsive wage changes; one that reflects the effect of market forces on the returns to characteristics only, and one that also includes the effect of market forces that takes place via composition/quantity effects. To our knowledge this is the first paper to put emphasis on this distinction.

We find substantial differences across countries regarding changes in the wage structure. Specifically, in the Netherlands, Germany, Greece, Italy and Belgium wage growth rates trend upwards along the wage distribution, with the consequent widening of wage inequality. In contrast, the wage distribution in Hungary, Ireland and Spain has become more compressed, as larger wage increases have taken place for low paid jobs. Lastly, the wage distribution in Austria has remained roughly unchanged. We also find that purely mechanical/predetermined compositional changes have hardly contributed to the determination of the observed wage changes. Wage changes have been generally driven by components that are responsive to economic factors. In fact, the compression of the wage distribution observed in Spain, Hungary and Ireland is mostly due to changes in return effects, while the widening of the distribution in the Netherlands, Germany and Greece is mostly attributable to composition effects that are not purely predetermined. These findings point to a relevant role for economic developments in shaping wage changes.

To provide further evidence, we relate changes in wages across countries with macroeconomic developments and structural trends. We do so using gross (observed) wage changes, as well as our two measures of market-responsive wage changes. We show that technological progress is associated with wage increases, with the effect being stronger for very high and very low paid jobs. Globalisation is also associated with wage increases, but less so for the lowest wages. In contrast, increases in migration are associated with declines in wages. Finally, the effect of labour market institutions on wage changes differs among institutional indicators; increases in union density bring about wage drops, while high levels of bargaining centralization or coordination are associated with wage increases.

The paper has the following structure. Section 2 describes the data and period of study. Section 3 discussed the methodological approach for measuring changes in the wage distribution. Section 4 presents the changes in wage structures in the nine EU countries, and the components of these

changes. Section 5 interprets these changes in relation to cross-country variability in institutions, macroeconomic and structural trends. Finally, Section 6 concludes.

2. Data and period of study

Our database comprises microdata from the *Structure of Earnings Survey* (SES henceforth) for two time waves. The SES data is collected at the firm level. A large random sample of firms from the Social Security General Register (or similar firm registers) is used to obtain information on both the firm's characteristics and on a random sample (ca. 20%, depending on the size of the firm) of their employees. Information obtained about the workers includes several measures of pay and hours of work, age, gender, and educational attainment. Information about the job or the employer refers to the type of contract, the sectoral and occupational classification, tenure, firm ownership status, firm size, the nature of the pay bargaining regime, etc.

The SES is uniquely suitable for our study for three reasons. Firstly, it is comparable across countries. The survey has been run by the national statistical office of 20 European countries on comparable basis, first occasionally and now every four years. Currently two harmonised waves are available, 1995 and 2002.[5] Secondly, the SES is a matched employer-employee database that allows us to estimate Mincer equations controlling for individual, job-specific and firm-specific features. In this way, we are able to purge observed wage changes of compositional changes in workers and job characteristics. Finally, the fact that the data are collected at the firm level means that the information on pay and earnings is more accurate than if they were collected from household surveys.

However, not all the data for EU countries and waves are made available for research. So far, we have been able to gain access to data for nine countries (Austria, Belgium, Germany, Greece, Hungary, Ireland, Italy, the Netherlands, and Spain).[6] After excluding outliers, the top and bottom 1% of wages, workers with missing/not accurate observations for some relevant variables, and those in sectors that were missing for most of the countries and or waves (mainly education, health and recreational activities), we end up with the country-samples sizes shown in Table 1. The large number of individual observations allows us to construct detailed measures of earnings including or

[5] The most recent wave of the SES (2006) has only become available very recently and for a small number of the countries in this analysis.

[6] Results for Greece have been borrowed from Christopoulou and Kosma (2009), which is also a WDN research paper, follows the same methodology and uses same data and codes as this paper. Estimations for Italy, Ireland and Spain were done at the Safe Center in Eurostat and the ones for Germany via remote access at Statistics Germany. Alfred Stiglbauer, Philip Du Caju, Steven Poelhekke and Gabor Katay were kind enough to run our codes on the Austrian, Belgian, Dutch and Hungarian SES data available at their respective national central banks.

excluding several kinds of wage components. It also helps with controlling for detailed personal and/or jobs characteristics so that changes in the remuneration of particular "tasks" can be measured.

Table 1. Sample size per country and wave

	1st wave			2nd wave		
	1995	**1996**	**1999**	**2001**	**2002**	**2005**
Austria		93,941			85,481	
Belgium			101,302			97,409
Germany	652,676			467,932		
Greece	38,071				41,449	
Hungary		91,578			119,019	
Ireland	36,727				16,359	
Italy	79,501				73,692	
Netherlands	66,196				37,860	
Spain	170,697				173,487	

The period of analysis, although imposed by data availability, is very interesting for the countries examined. It covers a phase of both substantial labour demand shocks (e.g. technological change and globalisation) as well as significant labour supply shocks (e.g. immigration, changes in the composition of the labour force by age, gender, and level of education etc.). Deregulation in product markets and labour market reforms have also been prevalent, affecting the way labour markets operate. Tables 2a and 2b document the time and cross-country variations in selected macroeconomic and labour market variables. In brief, 1995-2002 is a period of increasing openness (as shown by variations in the trade balance and the globalization index); increasing GDP growth only in Greece and Hungary; low productivity growth (even negative in Spain and Italy) with increasing contribution of Information and Communication Technologies (ICT); increasing female labour force participation; and large immigration flows in Greece, Ireland, Italy and Spain. Finally, during this period there is substantial cross-country heterogeneity in labour market institutions and, although the process of reform has reduced this heterogeneity to some extent, countries have progressed in different pace.

Table 2a. Indicators of growth, trade and technology

	Real GDP growth		Trade balance of goods and services as a % of GDP		Dreher Globalization index		TFP (value added based) growth		Contribution of ICT capital services to output growth	
Wave	1	2	1	2	1	2	1	2	1	2
Austria	2.23	1.65	-1.5	4.2	85.7	91.0	99.8	103.4	0.4	0.5
Belgium	3.42	1.85	3.1	2.7	93.1	92.1	98.6	97.4	1.1	0.6
Germany	1.89	1.24	-0.9	2.1	71.4	83.0	100.0	103.5	0.3	0.5
Greece	2.10	3.44	-2.4	-6.4	60.7	72.7				
Hungary	1.32	4.15	0.0	-3.9	75.3	80.1	105.8	124.3	-1.1	0.5
Ireland	9.63	6.43	10.4	16.7	78.7	84.0	100.0	112.8		0.1
Italy	2.83	0.45	3.9	0.1	71.3	79.3	100.0	98.4	0.2	0.2
Netherlands	3.12	0.08	6.2	5.2	88.0	89.7	100.0	101.6	0.3	0.3
Spain	2.76	2.70	-0.2	-3.8	75.2	82.7	100.0	94.8	0.3	0.2

Notes: Data for trade balance and real GDP growth are taken from OECD. Stat. The technology indicators are derived from the EUKLEMS 2008 database. The globalization index is from Dreher (2006).

Table 2b. Indicators of demographics and labour market institutions

	Female labour force participation rate		Proportion of foreign labour force		Union density		Bargaining coordination	Bargaining centralization
Wave/Year	1	2	1996	2002	1	2	2000	2000
Austria	61.5	63.9	10.0	10.9	40.1	35.4	2.0	2.0
Belgium	56.2	59.7	8.4	8.6	55.1		2.0	2.0
Germany	61.5	64.3	8.9	9.2	29.2	23.5	2.5	2.0
Greece	45.2	51.6	3.7	5.5	29.2	23.2		
Hungary	50.2	52.9	0.5	1.0	63.4	19.9		
Ireland	47.8	57.8	3.5	5.5	47.1	35.7	3.0	3.0
Italy	42.8	48.4	2.9	3.8	38.1	34.0	2.5	3.0
Netherlands	59.3	66.7	3.9	3.7	25.7	22.1	3.0	2.0
Spain	47.5	53.9	1.0	4.5	16.3	13.9	2.0	2.0

Notes: Data for female labour force participation and proportion of foreign labour force are taken from *OECD. Stat*. Union density, bargaining centralization and bargaining coordination indicators are from the OECD-CEP (2006) database, supplemented with some data from national sources for Greece and Hungary.

3. Methodology

Observed wage changes can be thought as the result of the changes due to the different characteristics of workers and jobs and the changes in the returns to those characteristics. To separate these two components we rely on the estimation of extended Mincer (1974) equations for log (real) hourly wages using quantile regressions, as follows:

$$\ln w_{it}^{\vartheta} = Q^{\theta}(\ln w_{it} / X'_{it}) + \varepsilon_{it} = a_{it}^{\vartheta} + \sum_{j} \beta_{jt}^{\vartheta} X_{jit}^{\vartheta} + \varepsilon_{ti} \ , \quad Q^{\theta}(\varepsilon_{t} / X'_{it}) = 0 \tag{1}$$

where w_{it} is the wage of individual i in year t, $Q^{\theta}(\ln w_{it} / X'_{it})$ refers to the quantile of wages conditional on the vector of characteristics X_{it} and ϑ denotes the quantile. α is a constant, and ε is the stochastic error.

We have used three different variables measuring individual wages: basic hourly wage excluding payment for overtime; hourly wage including regular bonuses and payment for overtime; and hourly wage including irregular bonuses and other complements. We only show here results for hourly wage including regular bonuses and payment for overtime. We choose this variable for the sake of comparability with other SES studies that have also used it, and because we can construct it for practically all the countries and waves of our sample.[7] The covariates, X_{jit}, include workers' characteristics and employers' and job observable features, in most occasions captured by

[7]Except for Hungary, for which we cannot calculate the payment for overtime in the first wave (1996) and we use a measure that excludes these payments. Nevertheless we believe that this is a good proxy because paid overtime is very low in Hungary and the variables with and without overtime payment in 2002 are very similar.

dummies.[8] We apply the procedure proposed by Machado and Mata (2005) that partitions the observed changes in the distribution of wages into quantity (changes in characteristics) and price (changes in returns) components. Machado and Mata (2005) do this via simulations based on mean characteristics of the individuals who are in each one of the quantiles of the wage distribution.[9] Taking averages by quantile and subtracting between two periods, equation (1) yields:

$$\ln w_{t_1}^{\vartheta} - \ln w_{t_0}^{\vartheta} = (a_{t_1}^{\vartheta} - a_{t_0}^{\vartheta}) + \sum_j \beta_{t_1}^{\vartheta}(\overline{X}_{jt_1}^{\vartheta} - \overline{X}_{jt_0}^{\vartheta}) + \sum_j (\beta_{t_1}^{\vartheta} - \beta_{t_0}^{\vartheta})\overline{X}_{jt_0}^{\vartheta} + (\overline{\varepsilon}_{t_1}^{\vartheta} - \overline{\varepsilon}_{t_0}^{\vartheta}) \quad (2)$$

where w_t^{ϑ} is the ϑ^{th} quantile of the wage distribution in year t, $\overline{X}_{jt}^{\vartheta}$ is the vector of mean characteristics of quantile ϑ and year t, and $\overline{\varepsilon}_t^{\vartheta}$ is the mean of the unobserved component. From this, the wage change for each quantile can be decomposed into:

- A quantity component (the composition effect): $\sum \beta_{t_1}^{\vartheta}(\overline{X}_{jt_1}^{\vartheta} - \overline{X}_{jt_0}^{\vartheta})$. This represents the wage changes that would have occurred due to changes in employer or employee observable characteristics if the returns to these characteristics had remained unchanged. Composition effects may reflect mechanical changes that do not respond to market forces (e.g. predetermined or largely predetermined changes in the composition of education, age, sex of the labour force etc.) or they may reflect adjustments that respond to economic developments (e.g. sectoral shifts, changes in type of contracts, etc.).
- A price component (the returns effect): $(a_{t_1}^{\vartheta} - a_{t_0}^{\vartheta}) + \sum (\beta_{t_1}^{\vartheta} - \beta_{t_0}^{\vartheta})\overline{X}_{jt_0}^{\vartheta}$. This is due to changes in the returns to the characteristics only. Specifically, under the assumption that the characteristics remained unchanged, this term includes changes in the constant (i.e due to changes in unobservable features common among all employees and/or changes in the coefficients of the omitted dummies) and changes in the returns to the observable characteristics. Price or returns effects arise exclusively from shifts in supply and demand and from institutional changes.

[8] The covariates included in the wage regression are: age, gender, education, tenure, two-digit industry dummies, type of contract (permanent vs. temporarily), firm size, region, occupation dummies (one-digit or more aggregated, up to seven dummies), market (local, regional, national international), public firm, and full vs. part time workers. Interactions among covariates are not included. We acknowledge that controlling for both worker and job characteristics may introduce selection bias (SB) reflecting that worker characteristics may change the composition of job characteristics (Angrist and Pischke 2009, section 3.2). We include job characteristics in the regression under the understanding that there is a trade-off between the omitted variable bias (OVB) that is present when only worker characteristics are included and the SB. The OVB is most likely to be positive (the coefficients on worker characteristics are inflated by premia/penalties associated with omitted employer characteristics), while the SB is expected to be negative (the sorting of specific types of workers in specific types of firms moderates the estimated effects of worker-specific characteristics). Indeed, including job's characteristics slightly reduces the coefficients of some individual characteristics (smaller OVB and/or a negative SB).

[9] The Machado and Mata method is an extension of the canonical Oaxaca (1973) decomposition of effects on mean wages to the entire wage distribution. Autor, Katz and Kearney (2005) show that the Machado- Mata decomposition corrects shortcomings of the original Juhn, Murphy and Pierce (1993) decomposition and nests the Kernel reweighing in DiNardo, Fortin and Lemieux (1996), Lemieux (2002) and Lemieux et al (2007).

- An unobserved or residual component: $(\bar{\varepsilon}^{g}_{t_1} - \bar{\varepsilon}^{g}_{t_0})$. This is due to changes in the remaining unobserved factors determining wages, which are not common among employees.

These counterfactual decompositions are accounting decompositions based on the estimated model (1), and their validity relies on the partial equilibrium assumption that prices and quantities can be seen as independent. This could introduce some bias in the estimation of the components as it ignores the feedback between composition and returns.

4. Wage changes and their components

Figure 1 provides an overview of the magnitude and patterns of the changes observed at each decile of the wage distribution in observed (log) hourly wage (incl. overtime), in hourly wage net of predetermined compositional changes, and in the part of hourly wage attributable to price effects only. Figure 1a refers to the whole sample, while figures 1b and 1c refer to the males and females sub-sample, respectively.[10]

Observed changes in real wages during the sample period (solid line) have been mostly positive along the whole range of wage levels in the nine countries of our sample, with the only exceptions being wages of the lowest paid jobs in Germany and Greece and wages in the middle part of the wage distribution in Spain. Both the magnitude and shape of the changes observed in real wages differ substantially across countries. Observed real wages in the Netherlands, Germany, and Greece trend upwards along the wage distribution. The consequent increase in wage inequality is of similar or larger magnitude to the increase in wage inequality observed in the US over the same period (Autor, Katz and Kearney, 2008).[11] A widening of the observed wage distribution is also observed in Belgium and Italy, but is less pronounced. In contrast, the wage distribution in Hungary, Ireland, and to a lesser extent in Spain has become more compressed. In fact, the observed increase in real wages in these countries has been lowest in the middle part of the wage distribution while the largest increases have taken place for low paid jobs. Finally, in Austria wage changes from 1996 to 2002 are positive, very small and similar along the whole distribution with no noticeable effect on wage inequality.

[10] In addition, a set of summary indicators of changes in the wage distribution by country is presented in Table A1 in the Appendix.

[11] Figure 3 in Autor, Katz and Kearney (2008) shows that the log 90/50 wage ratio for American men increased substantially over 1995-2002 (by 0.7-0.9 points depending on the database used for the calculations), while the change in lower-tail inequality was minimal (the log 50/10 wage ratio increased only by 0-0.2 points). These developments were similar to those in Greece, while Germany and the Netherlands experienced comparably large changes in overall inequality, the bulk of these changes took place at the lower end of the distribution.

This diversity in the patterns of wage changes across countries suggests that there might be an analogous diversity in the forces driving the observed changes. More specifically, the upward sloping pattern of wage changes along the wage distribution in Germany, Greece, Italy, Belgium and the Netherlands, is a standard symptom of the conventional skill-bias technical change hypothesis, suggesting the presence of forces that favour the more skilled and better paid workers. In contrast, the "U-shaped" pattern of the wage changes along the wage distribution observed in Spain, Hungary, and Ireland is an indication of the "routinization" hypothesis; i.e. it has been typically identified as being driven by technological changes that replace routine jobs or jobs that require intermediate skills, generally found in middle-wage jobs. Finally, the absence of any substantial movement in wage inequality in Austria could raise considerations regarding labour market institutions.

It is clear, however, that, in order to obtain reliable evidence on how the wage structure has been adjusting in response to cross-country variability in macroeconomic developments and institutional changes, it is necessary to 'clean' the observed wage changes from the influence of predetermined compositional changes that are not responsive to market forces. This is something that is customarily done in the literature of wage inequality when analysing "residual inequality" (or inequality within the same age, education and gender groups). The standard procedure involves estimating 'simple' Mincerian equations (i.e. wage equations controlling only for employee characteristics) and "conditioning out" the part of the observed wage changes that is due to changes in the age, gender and education composition of the labour force.

As mentioned in our methodology section, we take advantage our rich database and depart from the inequality literature by controlling for both worker and job characteristics.[12] This enables us to estimate the compositional changes both of the employee characteristics, which can be assumed as predetermined, and of the job/employer characteristics, which are expected to be largely responsive to economic developments. Thus, we are able to define the two alternative measures of composition-conditional wage changes also plotted in Figure 1. The first one, displayed as a line with solid squares, represents wage changes net of the composition effects of age, education, gender, and region, (i.e. the characteristics that we regard to be predetermined or largely

[12] The estimated models work, overall, rather well. The residuals explain a very small proportion of the total change. See figures A1a-A1c in the Appendix for the break down of the wage changes by country - a more detailed decomposition is available from the authors.

predetermined) and is bound to include some 'noise'.[13] The second one, displayed as a line with hollow squares, represents the part of changes in wage attributable to price or returns effects only. These are net of (i) the composition effects of all the variables in the regressions, including both predetermined characteristics (as above) and a large number of characteristics that cannot be regarded as irresponsive to economic developments; and (ii) of a small error term from the estimation.

As can be clearly seen in Figure 1a, wage changes net of exogenous or predetermined compositional effects are either overlapping with observed (gross) wage changes or are more or less parallel to them.[14] The only exceptions are the Netherlands at the first wage decile, and Austria, where gross wages there have moved very little. This evidence suggests that predetermined compositional effects have played hardly any role in shaping the distribution of wage changes, only in Ireland and Italy, where the two lines are parallel, predetermined compositional effects have affected the mean wage but left unchanged the external shape of the distribution. This is despite the fact that exogenous changes in the employment composition over this period have been large. Our sample shows that there has been a significant rise in the share of female employment, most noticeably in Southern European countries, Ireland, and the Netherlands, but also in Central Europe, especially among the top deciles. Moreover educational levels, as measured by years of schooling, increased in all the deciles of the wage distribution for all countries (with the only exception of the Netherlands, in the lowest deciles). Finally, there is also an increasing trend in employee's age (except for Spain and Greece).[15]

The small role played by predetermined composition effects suggests that observed wage changes are mostly shaped by those wage components that are responsive to market forces and institutional changes. When looking at the returns effects it appears that for the Netherlands, Germany and Greece these are roughly constant along the whole wage distribution, thus, suggesting that the observed increase in wage inequality is mostly attributable to compositional changes that are not

[13] Separating predetermined from market-responsive composition effects requires some personal judgment. We have chosen to be 'conservative' on what we classify as a predetermined characteristic (mainly the employee characteristics that are usually included in 'simple' Mincer equations and region), because the composition of the remaining characteristics (tenure, sector, occupation, firm size, contract type, firm ownership) is expected to be significantly affected by market forces. Still, market forces are not expected to be solely responsible for the entire compositional shift in these characteristics – a part of this shift is bound to be mechanical, thus introducing 'noise' in the net measure of wage changes, if that is to be taken as reflecting market-driven wage changes.

[14] Similar patterns, with small variations prevail if only the effects of age, gender, and education are conditioned out from observed wages after estimating the extended version of equation (1), as well as after estimating a simple Mincer equation, including only workers characteristics.

[15] See Table A2 in the Appendix.

purely exogenous to economic conditions.[16] These compositional changes have been negative for the low and middle wage jobs in all three countries, mostly due to changes in tenure levels for Greece; change in firm size and permanent contracts composition for Germany; and changes in permanent contracts and sectoral composition for the Netherlands.

In Ireland, Hungary and Spain the return effects display a U-shape similar to the one of observed wage changes or even strengthened. Return effects are the predominant force explaining the compression of the wage distribution in these countries, while composition effects have a less but not negligible contribution. More specifically, in Spain market-responsive composition-effects also form a U-shape pattern across the distribution, reinforcing the contribution of the returns effects to wage compression. In Hungary, these composition effects have been sizeable enough across the distribution to keep wage changes subdued, while in Ireland, composition effects account for some improvement of wages at the top of the distribution. In the case of Spain, the largest negative component of the changes in wages is due to changes in tenure composition, while in Hungary, other job characteristics dominate the compositional effects.

In Belgium and Italy the predominant force explaining the slight widening of the observed wage distribution is also the return effects, while composition effects vary across the wage distribution. Interestingly, in Italy the two effects work against each other. Market-responsive composition effects work towards lower wage inequality, while return effects work towards higher wage inequality and dominate, thus resulting in the mild widening of the wage distribution. In Belgium the two effects reinforce each other, both being upward sloping along the wage distribution. Finally, in Austria, the very small wage changes from 1996 to 2002 do not hide any composition and return effects working in opposite directions; simply, these components hardly change along the wage distribution.

It is notable that, while composition effects have been negative in Ireland, Belgium, Italy and Austria (very small in the last three cases), returns effects have been positive for all the nine countries of our sample, except for Italy at the lower end of the wage distribution. This result for Italy is consistent with the opening wage gap between younger new entrants and older workers in Italy as documented in Rosolia and Torrini (2008).

[16] Apart from exogenous changes in employment composition, Table A2 also shows that not-purely-exogenous changes have also been substantial, e.g. those regarding job-specific tenure and type of job (permanent and full-time versus temporary and part-time). Other such changes, e.g. regarding sectors of activity, and occupations (not reported) are also prevalent.

Figure 1a. (Log) Wage changes by decile, all

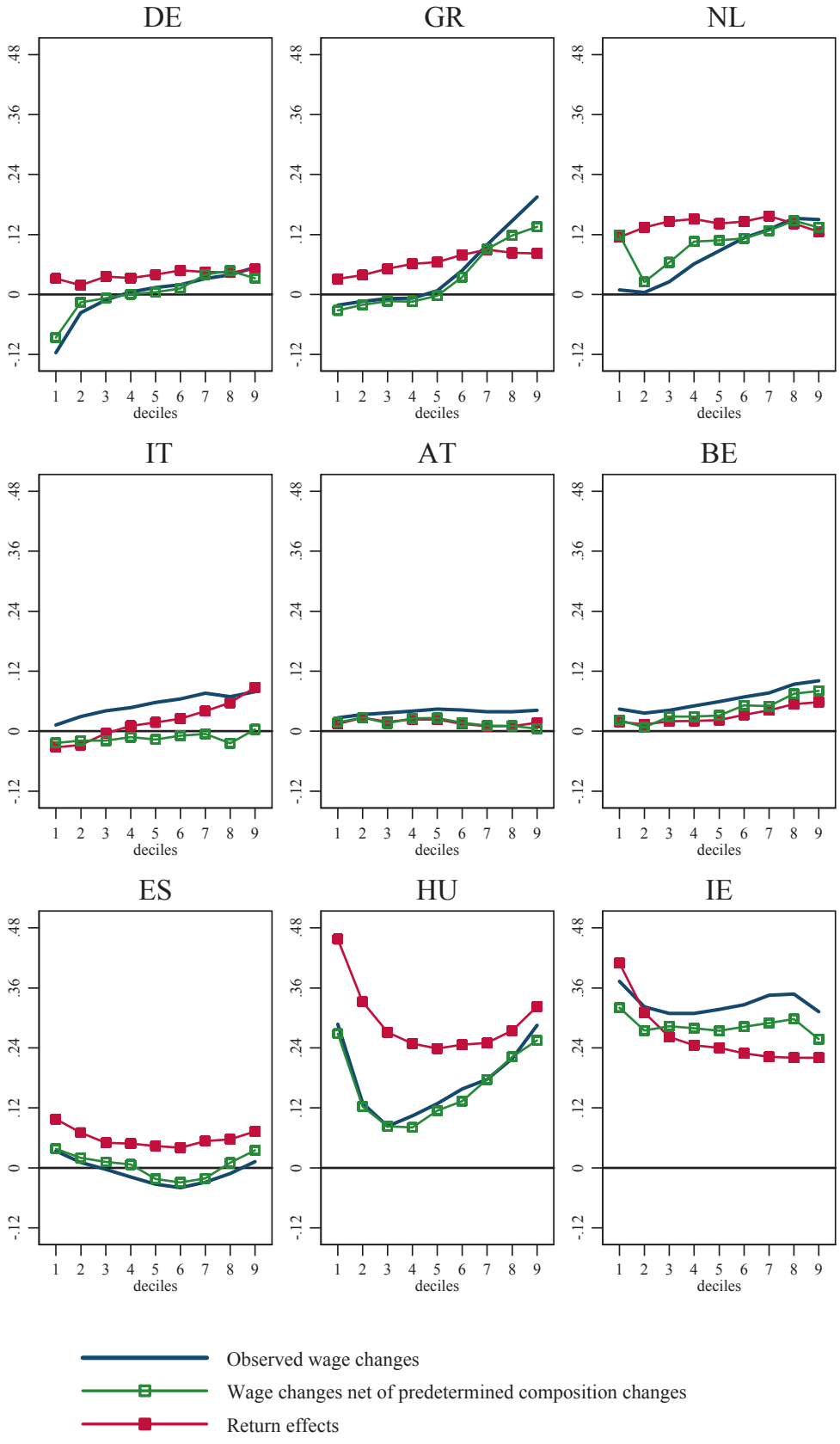


Figure 1b. (Log) Wage changes by decile, males

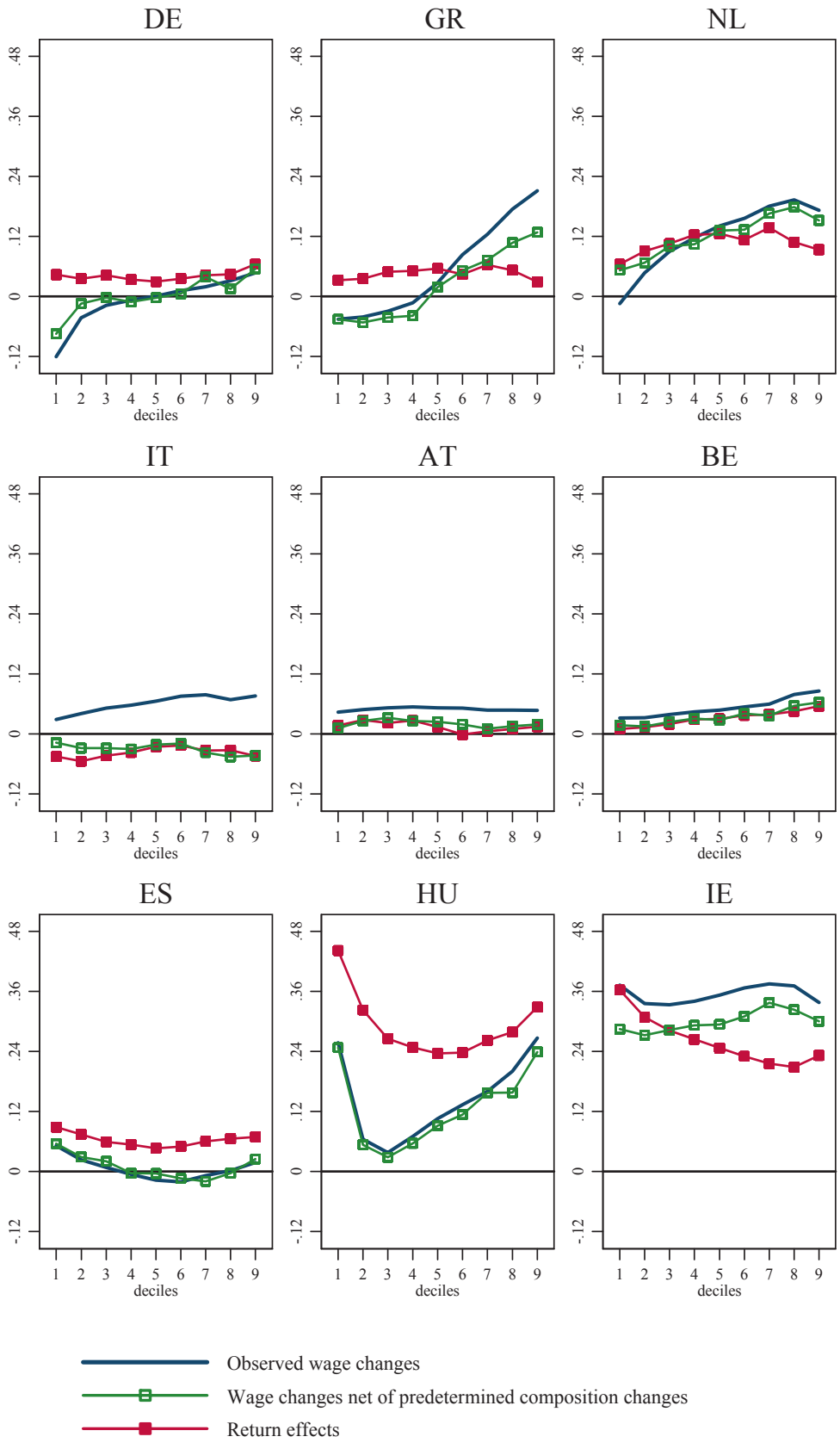
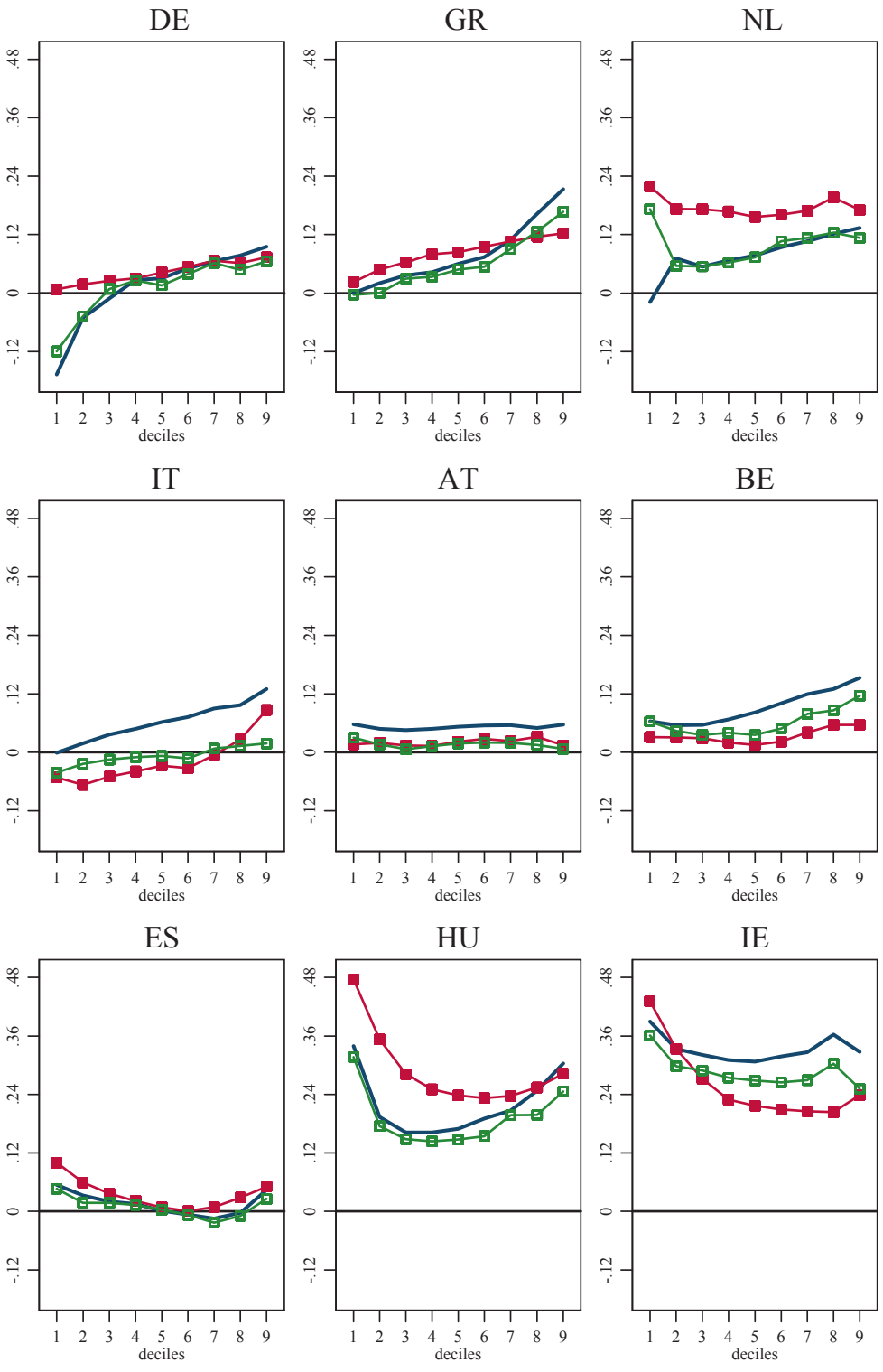


Figure 1c. (Log) Wage changes by decile, females



In order to give a more general view of the changes in wages reported above, Table 3 summarizes mean changes in each of the our three wage measures (observed wage changes, wage changes net of predetermined compositional changes and wage changes due only to returns) across countries in three segments of the wage distribution; the three lowest, middle, and top deciles (conditional on country effects)[17]. For observed wages and wage-changes net of predetermined compositional changes, regardless of the sample used (all, males, and females), the changes are increasing along the distribution. However, once all compositional effects and any non-observables are "purged out", there is clear evidence of some "polarisation" in the distribution of wage changes, with highest increases at the three lowest and the three top deciles.[18]

Table 3. Mean Observed Wage Changes and Mean Changes in Returns

	ALL			MALES			FEMALES		
	Observed wage changes	Net wage changes	Changes in returns	Observed wage changes	Net wage changes	Changes in returns	Observed wage changes	Net wage changes	Changes in returns
three lowest deciles	-0.031	-0.017	0.038	-0.040	-0.016	0.046	-0.033	-0.017	0.041
	[0.016]*	[0.012]	[0.009]***	[0.014]**	[0.011]	[0.006]***	[0.026]	[0.021]	[0.016]**
three middle deciles	-0.001	-0.003	0.032	-0.010	-0.006	0.032	0.016	0.011	0.031
	[0.009]	[0.007]	[0.006]***	[0.008]	[0.004]	[0.005]***	[0.012]	[0.010]	[0.008]***
three top deciles	0.032	0.030	0.045	0.023	0.025	0.046	0.056	0.039	0.055
	[0.008]***	[0.008]***	[0.004]***	[0.009]**	[0.009]**	[0.003]***	[0.015]***	[0.012]***	[0.009]***
R-squared	0.84	0.85	0.95	0.83	0.82	0.96	0.82	0.81	0.92

Note: Net wage changes are wage changes net of predetermined compositional changes. Regressions include country fixed effect. Country omitted: Germany. Total observations: 81. Standard Errors clustered at the country level are in brackets. * significant at 10%; ** significant at 5%; *** significant at 1% . Weighted by the average sample size of the regressions used to compute changes in returns.

5. Explaining changes in the wage structure

In this section, we make an attempt at associating cross-country differences in wage changes with some candidate causal factors. As mentioned already, there are several theories about the causes of the changes in the wage distribution. Most of the empirical literature refers to skill-biased technological change and to labour market institutions. Since European countries have been subject to such changes to different degrees, we can exploit the observed cross-country variability in wage changes across countries to account for the role of these macroeconomic and structural medium-run trends in shaping the observe wage changes. Thus, we can document to what extent the wage

[17] Table 3 presents the coefficients of the regressions of each measure of wage changes for each decile (9x9 observations) on three dummies: one for the three lowest deciles, another for the three middle deciles and one for the three top deciles.

[18] This is likely to be driven by Hungary and Ireland; when dropping these countries from our sample the U shape turns into an upward sloping pattern.

determination process has accommodated those trends by changing either the relative composition of particular characteristics or the relative remuneration of particular "tasks".

Given the wide set of proposed hypothesis to explain changes in the wage structure, there could be many plausible factors to consider. Here we focus on five: growth, demographics, globalisation, technology and institutional change. The relevant indicators by country have been presented in Tables 2a and 2b. As is typical in international comparisons of changes in wage structures, the number of countries for which we calculate wage changes is much lower than the number of potential explanatory indicators. Thus exploring the statistical association between the two is problematic. The wealth of our microeconomic data helps ameliorate this problem. For each of the nine countries of our sample, we use measures of wage changes at different positions (deciles) of the wage distribution to increase degrees of freedom. The added benefit of this is that it enables us to investigate if macroeconomic and institutional developments have had a differential impact in different segments of the labour market (i.e. on low-paid and high-paid workers). We apply the analysis for all three measures of wage changes. Thus, we estimate the following set of regressions:

$$\Delta w_s^{\theta} = \lambda_s + \lambda_{\vartheta'} + \sum_{j=1}^{3} \beta_j \lambda_{\vartheta'} x_s + \varepsilon_s \qquad (3)$$

where Δw^{θ}_s are alternative measures of the wage change at decile θ in country s, λ_s is a country dummy, $\lambda_{\theta'}$ is a dummy for position at the wage distribution (three lowest, middle and top deciles, indexed by j=1,2,3) and x_s is a variable representing either demographic, macroeconomic or institutional changes. We include each covariate separately in alternative regressions. Standard errors are computed by clustering at the country level.

Some results are displayed in Tables 4 to 8 below. There are four kinds of information contained in these results. Firstly, there is the issue of the impact of each particular factor on wages. Secondly, we can observe the association of each factor with each of the three different wage measures; that is, observed wage changes, wage changes net of predetermined compositional changes and wage changes due only to returns. Thirdly, as we run two sets of regressions, one for males another for females, we can observe any "gender-bias" in the change of the wage distribution. Finally, as mentioned above, we can investigate the different impact of each factor on workers' wages at different deciles of the wage distribution.

We start by relating changes in the wage structure to GDP growth (Table 4). For both overall wage changes and wage changes net of predetermined composition effects, there seems to be a negative statistical association along the whole wage distribution, so that real wage growth is lower in high-growth countries. However, changes in returns, once other composition effects are taken into account, are positively related to growth but only in the lowest deciles of the wage distribution. Admittedly, our sample contains only nine countries, and the high-growth countries (Ireland, Spain, and Hungary) are rather heterogeneous as far as the sources of growth in this period are concerned.[19] The previous result, nevertheless, suggests that studies focusing on the impact of growth on the wage structure should explicitly uncover the effects working through changes in the composition of "job-workers" matches and changes in the "price" of those matches.

For the rest of the results (Tables 5 to 8), the estimates confirm the statistical association between wage changes and the concurrent demographic, macroeconomic and structural trends. Female labour participation, globalisation, technological change, centralization and coordination of collective bargaining are positively associated with wage changes, while immigration and changes in union density are negatively associated with them.[20] Given that all measures of wage changes are on average positive, these estimated correlations suggest that the expansion in female labour force participation, the increase in trade openness, the sustainment of high levels of coordination and centralization in bargaining, and the weakening of union density observed in all countries over the examined period, have contributed towards higher wage increases all along the wage distribution. The same holds for the acceleration in technical change observed only in Austria, Hungary, Ireland and the Netherlands. In contrast, the general increase in the proportion of foreign labour force, and the deceleration in technological change observed in Belgium, Italy, and Spain have contributed towards lower wage increases.

Notably, the association of technological change and change in union density is strongest with pure changes in returns, weaker with wage changes net of predetermined compositional effects, and weaker still with changes in observed wages. In other words, the association is stronger the 'purer' the measure of market-driven wage changes. Technology and labour unions seem, therefore, to affect wages mostly via changes in returns. On the contrary, changes in observed wages associated

[19] During the sample period, Ireland growth was based on higher productivity growth and a housing boom, Spain growth was demand-driven, credit-fuelled, supported by large immigration flows and with very low productivity growth, and Hungary is the case of a catching-up economy, exploiting the gains from transition to a market economy.
[20] The opposite signs in the estimated coefficients between union density and bargaining centralization/coordination is consistent with the literature on the Calform and Driffils (1988) hypothesis and the related empirical evidence, according to which highly coordinated and centralised wage bargaining can increase bargainers' awareness of the macro-level consequences of wage arrangements, and thus lead to 'bargained flexibility'.

with centralization levels, changes in female participation, and changes in the trade balance are generally larger than the corresponding wage changes net of predetermined compositional effects, and these are, in turn, larger than the changes in pure returns. The implication is that these forces affect wages via both price-effects and compositional changes. For the remaining variables no particular pattern is observable.

As far as gender differences are concerned, we do not find any striking evidence. In the majority of cases, the examined forces affect male and female wage changes in the same direction and with similar magnitude. The only notable exception concerns immigration, which shows a stronger negative association with price-effects in the case of females than males.

Finally, regarding differences along the wage distribution, we find that the association of wage changes with globalization is stronger at the top of the wage distribution, a pattern consistent with the conventional skill-biased technical change hypothesis. Against expectations, we also find that wage changes are more strongly correlated with immigration at the top of the distribution, whereas one would assume that foreign workers in Europe are on average low skilled and would, instead, affect wage changes more at the bottom of the distribution.[21] More intuitively, we find that the variables capturing technological changes, and especially changes in the contribution of ICT capital to GDP growth, are positively associated with wage changes, with a larger coefficient at the top and bottom of the distribution (generating a U shape). This constitutes direct evidence in favour of the "routinization" hypothesis that technological change benefits mostly non-routine jobs which are more prevalent at the tales of the wage distribution. It comes as a complement to recent evidence of polarization on the employment-side of labour market outcomes in Europe provided by Goos, Manning, and Salomons (2009).

Table 4. Regressions on real output growth

	ALL			MALES			FEMALES		
Dependent variable	Observed wage changes	Net wage changes	Changes in returns	Observed wage changes	Net wage changes	Changes in returns	Observed wage changes	Net wage changes	Changes in returns
three lowest deciles	-0.019	-0.017	0.017	-0.032	-0.027	0.015	-0.009	-0.010	0.018
	[0.004]***	[0.003]***	[0.006]**	[0.005]***	[0.004]***	[0.004]***	[0.007]	[0.007]	[0.009]*
three middle deciles	-0.035	-0.030	-0.003	-0.044	-0.036	-0.005	-0.027	-0.021	-0.0002
	[0.003]***	[0.003]***	[0.004]	[0.002]***	[0.002]***	[0.002]*	[0.005]***	[0.005]***	[0.005]
three top deciles	-0.023	-0.014	0.001	-0.029	-0.022	0.005	-0.021	-0.016	-0.003
	[0.004]***	[0.003]***	[0.003]	[0.005]***	[0.004]***	[0.002]*	[0.003]***	[0.003]***	[0.005]
R-squared	0.85	0.86	0.96	0.84	0.83	0.97	0.82	0.82	0.93

Note: Standard errors clustered at the country level are in brackets. * significant at 10%; ** significant at 5%; *** significant at 1% . Weighted by the average sample size of the regressions used to compute changes in returns. Real GDP growth is taken from OECDStat.

[21] Note that there is a small mismatch in the period for which data is available for the dependent wage variables and the immigration growth variable, which could be accountable for this odd result.

Table 5. Regressions on demographic variables

Dependent variable	Observed wage changes		Wage changes net of pred/ned compositional changes		Total returns effects	
Independent variable	Change in female participation	Change in foreign labour force	Change in female participation	Change in foreign labour force	Change in female participation	Change in foreign labour force
			All			
Interacted with three lower deciles	0.045	-0.003	0.039	-0.011	0.029	-0.016
	[0.008]***	[0.003]	[0.005]***	[0.003]**	[0.005]***	[0.003]***
Interacted with three middle deciles	0.034	-0.033	0.032	-0.032	0.026	-0.026
	[0.003]***	[0.003]***	[0.003]***	[0.002]***	[0.002]***	[0.002]***
Interacted with three highest deciles	0.034	-0.037	0.028	-0.037	0.026	-0.024
	[0.003]***	[0.002]***	[0.002]***	[0.002]***	[0.002]***	[0.002]***
R-squared	0.85	0.88	0.86	0.88	0.95	0.95
			Males			
Interacted with three lower deciles	0.046	-0.010	0.039	-0.014	0.028	-0.007
	[0.008]***	[0.003]***	[0.006]***	[0.002]***	[0.004]***	[0.003]**
Interacted with three middle deciles	0.038	-0.039	0.034	-0.033	0.030	-0.013
	[0.003]***	[0.002]***	[0.002]***	[0.001]***	[0.002]***	[0.002]***
Interacted with three highest deciles	0.036	-0.044	0.030	-0.043	0.025	-0.015
	[0.003]***	[0.002]***	[0.003]***	[0.002]***	[0.001]***	[0.002]***
R-squared	0.84	0.86	0.83	0.85	0.96	0.96
			Females			
Interacted with three lower deciles	0.053	0.010	0.045	-0.005	0.035	-0.025
	[0.010]***	[0.008]	[0.007]***	[0.007]	[0.007]***	[0.005]***
Interacted with three middle deciles	0.036	-0.025	0.031	-0.027	0.025	-0.043
	[0.002]***	[0.004]***	[0.002]***	[0.006]***	[0.001]***	[0.003]***
Interacted with three highest deciles	0.033	-0.036	0.027	-0.040	0.025	-0.046
	[0.003]***	[0.003]***	[0.002]***	[0.003]***	[0.002]***	[0.003]***
R-squared	0.84	0.86	0.84	0.85	0.92	0.93
Decile fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Country fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Observations	81	81	81	81	81	81

Notes: Standard errors clustered at the country level are in brackets. Data for female labour force participation rate and proportion of foreign labour force is taken from OECD.Stat. All remaining information as in Table 3.

Table 6. Regressions on trade openness variables

Dependent variable	Observed wage changes		Wage changes net of pred/ned compositional changes		Total returns effects	
Independent variable	Change in Dreher globalization index	Change in trade balance as a % of GDP	Change in Dreher globalization index	Change in trade balance as a % of GDP	Change in Dreher globalization index	Change in trade balance as a % of GDP
	All					
Interacted with three lower deciles	0.003	0.023	0.002	0.021	0.004	0.018
	[0.003]	[0.003]***	[0.003]	[0.003]***	[0.003]	[0.003]***
Interacted with three middle deciles	0.008	0.031	0.005	0.028	0.007	0.022
	[0.002]***	[0.002]***	[0.002]***	[0.001]***	[0.001]***	[0.002]***
Interacted with three highest deciles	0.007	0.027	0.005	0.024	0.006	0.018
	[0.001]***	[0.003]***	[0.001]***	[0.003]***	[0.001]***	[0.002]***
R-squared	0.85	0.86	0.86	0.86	0.95	0.95
	Males					
Interacted with three lower deciles	0.003	0.026	0.001	0.024	0.004	0.020
	[0.003]	[0.003]***	[0.003]	[0.003]***	[0.002]	[0.002]***
Interacted with three middle deciles	0.008	0.033	0.003	0.029	0.004	0.022
	[0.002]***	[0.001]***	[0.002]*	[0.001]***	[0.001]***	[0.002]***
Interacted with three highest deciles	0.008	0.029	0.004	0.028	0.004	0.021
	[0.001]***	[0.003]***	[0.001]**	[0.003]***	[0.001]***	[0.001]***
R-squared	0.84	0.84	0.82	0.83	0.96	0.96
	Females					
Interacted with three lower deciles	0.001	0.017	-0.001	0.016	0.002	0.012
	[0.005]	[0.005]***	[0.004]	[0.004]***	[0.004]	[0.004]**
Interacted with three middle deciles	0.011	0.029	0.009	0.026	0.008	0.021
	[0.001]***	[0.002]***	[0.002]***	[0.002]***	[0.001]***	[0.001]***
Interacted with three highest deciles	0.011	0.028	0.008	0.025	0.009	0.019
	[0.001]***	[0.004]***	[0.001]***	[0.003]***	[0.001]***	[0.003]***
R-squared	0.85	0.84	0.86	0.84	0.93	0.93
Decile fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Country fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Observations	81	81	81	81	81	81

Notes: Standard errors clustered at the country level are in brackets .The globalization index is taken from Dreher (2006) and the trade balance on goods and services as a percentage of the GDP is taken from OECD.Stat. All remaining information as in Table 3.

Table 7. Regressions on technical change indicators

Dependent variable	Observed wage changes		Wage changes net of pred/ned compositional changes		Total returns effects	
Independent variable	Change in TFP (value added based) growth	Change in contribution of ICT capital services to output growth	Change in TFP (value added based) growth	Change in contribution of ICT capital services to output growth	Change in TFP (value added based) growth	Change in contribution of ICT capital services to output growth
	All					
Interacted with three lower deciles	0.005 [0.002]*	0.054 [0.014]***	0.008 [0.002]***	0.058 [0.009]***	0.016 [0.002]***	0.154 [0.008]***
Interacted with three middle deciles	0.005 [0.002]**	0.030 [0.011]**	0.007 [0.001]***	0.030 [0.009]**	0.012 [0.001]***	0.096 [0.008]***
Interacted with three highest deciles	0.008 [0.001]***	0.066 [0.006]***	0.011 [0.001]***	0.075 [0.006]***	0.012 [0.001]***	0.105 [0.003]***
R-squared	0.85	0.79	0.86	0.81	0.96	0.96
	Males					
Interacted with three lower deciles	0.003 [0.002]	0.036 [0.013]**	0.006 [0.002]***	0.036 [0.008]***	0.019 [0.001]***	0.149 [0.003]***
Interacted with three middle deciles	0.003 [0.002]*	0.022 [0.010]*	0.007 [0.001]***	0.023 [0.004]***	0.015 [0.001]***	0.092 [0.004]***
Interacted with three highest deciles	0.007 [0.001]***	0.066 [0.006]***	0.011 [0.001]***	0.067 [0.006]***	0.016 [0.001]***	0.113 [0.002]***
R-squared	0.85	0.77	0.85	0.75	0.97	0.97
	Females					
Interacted with three lower deciles	0.008 [0.004]*	0.075 [0.025]**	0.010 [0.003]***	0.074 [0.021]**	0.018 [0.003]***	0.156 [0.018]***
Interacted with three middle deciles	0.007 [0.002]***	0.037 [0.015]**	0.009 [0.001]***	0.043 [0.015]**	0.014 [0.001]***	0.098 [0.009]***
Interacted with three highest deciles	0.009 [0.002]***	0.060 [0.011]***	0.011 [0.001]***	0.061 [0.009]***	0.014 [0.001]***	0.092 [0.009]***
R-squared	0.82	0.78	0.82	0.77	0.93	0.94
Decile fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Country fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Observations	72	63	72	63	72	63

Notes: Standard errors clustered at the country level are in brackets. Data on Total Factor Productivity (value added based) growth , 1995=100, and on the contribution of Internet and Computer Technology capital services in output growth (percentage points) are derived from EUKLEMS 2008 database. All remaining information as in Table 3.

Table 8. Regressions on labour market institutions

Dependent variable	Observed wage changes			Wage changes net of predetermined compositional changes			Total price effects		
Independent variable	Change in union density	Bargaining coordination (2000 levels)	Bargaining centralization (2000 levels)	Change in union density	Bargaining coordination (2000 levels)	Bargaining centralization (2000 levels)	Change in union density	Bargaining Coordination (2000 levels)	Bargaining centralization (2000 levels)
					All				
Interacted with three lower deciles	-0.004	0.006	0.144	-0.004	0.029	0.139	-0.008	0.085	0.072
	[0.001]***	[0.046]	[0.032]***	[0.001]***	[0.041]	[0.025]***	[0.0002]***	[0.034]**	[0.052]
Interacted with three middle deciles	-0.002	0.107	0.124	-0.002	0.094	0.119	-0.005	0.104	0.075
	[0.001]***	[0.013]***	[0.005]***	[0.0002]***	[0.016]***	[0.007]***	[0.0002]***	[0.011]***	[0.011]***
Interacted with three highest deciles	-0.004	0.130	0.116	-0.004	0.109	0.096	-0.006	0.089	0.094
	[0.001]***	[0.004]***	[0.002]***	[0.0003]***	[0.005]***	[0.001]***	[0.0001]***	[0.004]***	[0.009]***
R-squared	0.85	0.87	0.83	0.86	0.86	0.84	0.96	0.94	0.94
					Males				
Interacted with three lower deciles	-0.002	0.006	0.155	-0.003	0.011	0.141	-0.008	0.090	0.109
	[0.001]***	[0.041]	[0.030]***	[0.001]***	[0.035]	[0.029]***	[0.0001]***	[0.029]**	[0.031]**
Interacted with three middle deciles	-0.001	0.116	0.140	-0.002	0.078	0.134	-0.005	0.098	0.110
	[0.0003]***	[0.011]***	[0.005]***	[0.0001]***	[0.012]***	[0.014]***	[0.0001]***	[0.012]***	[0.004]***
Interacted with three highest deciles	-0.003	0.138	0.122	-0.004	0.117	0.099	-0.006	0.088	0.084
	[0.0003]***	[0.005]***	[0.001]***	[0.0004]***	[0.005]***	[0.003]***	[0.0001]***	[0.003]***	[0.005]***
R-squared	0.84	0.90	0.85	0.83	0.89	0.86	0.97	0.96	0.96
					Females				
Interacted with three lower deciles	-0.005	-0.012	0.157	-0.005	0.016	0.145	-0.008	0.058	0.086
	[0.001]***	[0.085]	[0.055]**	[0.001]***	[0.073]	[0.044]**	[0.001]***	[0.058]	[0.064]
Interacted with three middle deciles	-0.002	0.104	0.116	-0.002	0.088	0.106	-0.005	0.089	0.068
	[0.0003]***	[0.018]***	[0.010]***	[0.0002]***	[0.023]***	[0.009]***	[0.0002]***	[0.011]***	[0.013]***
Interacted with three highest deciles	-0.004	0.139	0.122	-0.004	0.114	0.010	-0.004	0.095	0.096
	[0.001]***	[0.009]***	[0.004]***	[0.001]***	[0.008]***	[0.004]***	[0.0003]***	[0.006]***	[0.010]***
R-squared	0.82	0.80	0.76	0.82	0.77	0.74	0.94	0.90	0.89
Decile fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	72	63	63	72	63	63	72	63	63

Notes: Standard errors clustered at the country level are in brackets. Data on institutions are from the CEP-OECD(2006) institutions database. Union density is Union membership/Employment (series udnet_vis); bargaining coordination and centralization indexes range from 1 to 3 (series cow and cew, respectively). These series were supplemented with numbers from national sources for Greece and Hungary. All remaining information as in Table 3.

6. Concluding remarks

In this paper we document changes in the wage structure of nine EU countries over the period 1995-2002 using micro data on wages and on workers and jobs characteristics that are comparable across countries. We disentangle the composition effects and the returns effects that are behind observed wage changes and, exploiting the cross-country variability in this regard, relate different measures of wage changes to demographics, structural and macroeconomic trends.

Our results provide evidence on two fronts. First, given the nature of the data, they offer new insights on changes in the wage distribution across EU countries, and on whether these changes are mostly due to predetermined compositional changes, or due to market-driven changes either in the remuneration or in the composition of particular tasks and characteristics. In fact, this is the first time in the wage-inequality literature that sufficient emphasis is put on the issue of quantity-side/compositional responsiveness to economic developments, and an attempt to formally address this issue is made in a Mincerian equation framework. Secondly, our results inform the literature on how wage changes and their different components are associated with the strong demographic, structural, and macroeconomic trends that have taken place in Europe.

We find that real wages have increased from 1995 to 2002 along the whole range of wage levels in the nine countries of our sample, with the only exceptions being the wages of the lowest paid jobs in Germany and Greece and the wages in the middle part of the distribution in Spain. Both the magnitude and shape of the changes observed in real wages differ substantially across countries. While observed real wages in the Netherlands, Germany, Greece, Italy and Belgium trend upwards along the distribution, leading to a widening of the wage distribution, the wage distribution in Hungary, Ireland and Spain has become more compressed. In Germany, Greece, and the Netherlands, these changes are of comparable scale to the equivalent changes in the US over the same period. In contrast, the magnitude of changes is relatively small in Italy, Belgium and Spain, while in Austria there is virtually no change.

According to our decomposition results, the contribution of mechanical compositional changes to these wage dynamics has been minor. Instead, it is the contribution of market development that has been driving wage changes, mostly by affecting the returns to employee and jobs characteristics, but also by inducing compositional shifts.

The role of economic developments is confirmed when we examine the responsiveness of changes in the wage structure in EU countries to macroeconomic and structural trends. Among our most interesting results we find that observed changes in technology are positively associated with wage increases, with the effect being stronger for very high and very low paid jobs – a typical symptom of the routinization hypothesis. Globalisation is also associated with wage increases, but less so for the lowest wages. Finally, increases in migration are associated with declines in wages.

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APPENDIX

Table A1. Measures of wage inequality by country and sex-group

		All (Males & Females)					Males					Females				
		Std. Dev.	Median	P90/P10	P50/P10	P90/P50	Std. Dev.	Median	P90/P10	P50/P10	P90/P50	Std. Dev.	Median	P90/P10	P50/P10	P90/P50
AT	1996	0.36	2.23	1.52	1.22	1.24	0.34	2.30	1.46	1.18	1.24	0.35	2.07	1.53	1.21	1.26
	2002	0.37	2.28	1.52	1.23	1.24	0.35	2.35	1.45	1.18	1.23	0.36	2.13	1.51	1.20	1.25
	Change	0.01	0.04	0.00	0.01	-0.01	0.01	0.05	-0.01	0.00	-0.01	0.01	0.05	-0.02	-0.01	0.00
BE	1999	0.32	2.41	1.39	1.15	1.21	0.32	2.43	1.38	1.13	1.22	0.31	2.32	1.38	1.15	1.2
	2005	0.35	2.46	1.41	1.15	1.22	0.35	2.48	1.40	1.14	1.23	0.34	2.41	1.41	1.16	1.22
	Change	0.03	0.05	0.02	0.00	0.01	0.03	0.05	0.02	0.01	0.01	0.03	0.09	0.03	0.01	0.02
DE	1995	0.35	2.64	1.40	1.19	1.18	0.33	2.71	1.37	1.17	1.17	0.31	2.46	1.37	1.17	1.17
	2001	0.47	2.65	1.51	1.26	1.20	0.47	2.71	1.47	1.23	1.19	0.44	2.49	1.54	1.29	1.19
	Change	0.12	0.01	0.11	0.07	0.02	0.14	0.00	0.10	0.06	0.02	0.13	0.03	0.17	0.12	0.02
ES	1995	0.48	1.83	1.90	1.39	1.37	0.47	1.90	1.85	1.38	1.34	0.45	1.61	1.91	1.35	1.41
	2002	0.46	1.80	1.86	1.33	1.40	0.45	1.89	1.79	1.32	1.36	0.43	1.61	1.86	1.29	1.44
	Change	-0.02	-0.03	-0.04	-0.06	0.03	-0.02	-0.02	-0.05	-0.06	0.02	-0.02	0.00	-0.05	-0.06	0.03
GR	1995	0.38	1.88	1.69	1.30	1.30	0.38	1.98	1.67	1.32	1.27	0.32	1.67	1.59	1.21	1.31
	2002	0.47	1.89	1.85	1.33	1.40	0.48	2.01	1.86	1.37	1.36	0.41	1.73	1.74	1.25	1.39
	Change	0.09	0.01	0.16	0.02	0.10	0.10	0.03	0.20	0.06	0.09	0.09	0.06	0.15	0.04	0.08
HU	1996	0.53	5.82	1.27	1.12	1.13	0.53	5.89	1.27	1.13	1.12	0.51	5.74	1.26	1.12	1.12
	2002	0.53	5.95	1.25	1.09	1.15	0.55	5.99	1.26	1.10	1.15	0.50	5.91	1.23	1.08	1.14
	Change	0.00	0.13	-0.01	-0.04	0.02	0.01	0.11	-0.01	-0.03	0.02	-0.01	0.17	-0.02	-0.04	0.02
IE	1995	0.48[a]	2.11	1.84	1.36	1.35	0.50	2.20	1.79	1.34	1.34	0.45	1.98	1.78	1.35	1.32
	2002	0.47[a]	2.43	1.65	1.26	1.30	0.49	2.56	1.63	1.27	1.29	0.44	2.29	1.59	1.23	1.29
	Change	-0.01	0.32	-0.20	-0.10	-0.05	-0.01	0.35	-0.16	-0.07	-0.05	-0.02	0.31	-0.20	-0.12	-0.04
IT	1995	0.35	2.09	1.46	1.17	1.25	0.36	2.12	1.48	1.17	2.27	0.29	1.99	1.40	1.14	1.23
	2002	0.36	2.15	1.50	1.19	1.25	0.36	2.19	1.49	1.19	1.25	0.33	2.05	1.48	1.18	1.26
	Change	0.01	0.06	0.03	0.02	0.00	0.01	0.07	0.02	0.02	-1.01	0.04	0.06	0.08	0.04	0.03
NL	1995	0.43	2.41	1.50	1.24	1.22	0.40	2.47	1.44	1.19	1.21	0.43	2.20	1.55	1.28	1.21
	2002	0.49	2.49	1.57	1.28	1.23	0.47	2.61	1.54	1.27	1.21	0.47	2.28	1.64	1.34	1.23
	Change	0.07	0.09	0.07	0.04	0.02	0.07	0.14	0.09	0.08	0.00	0.04	0.08	0.10	0.06	0.02

Note: Median figures are in euros for al countries except for HU, for which they are measured in national currency (HUF). [a] indicates inferred number.

Table A2. Means/proportions of selected employee (sex, education, age, tenure) and job (firm ownership, contract type) characteristics by country and decile

Deciles	10		20		30		40		50		60		70		80		90	
Waves	w1	w2	w1	w2	w1	w2	w1	w2	w1	w2	w1	w2	w1	w2	w1	w2	w1	w2
AUSTRIA																		
Females	57.2	70.4	41.0	53.0	32.2	39.0	25.0	32.8	24.2	29.2	23.8	30.4	21.8	28.4	23.4	26.4	20.6	21.4
Years of education	9.5	9.7	9.9	10.0	9.9	10.3	10.1	10.2	10.2	10.4	10.4	10.7	10.4	11.1	10.9	11.3	11.2	11.8
Years of age	34.5	36.5	33.8	36.1	34.4	36.0	35.1	37.3	35.3	36.9	37.3	38.5	38.4	38.5	40.0	40.6	42.1	41.9
Years of job-specific tenure	5.3	5.5	6.2	6.1	7.0	7.6	8.5	8.2	8.9	8.9	10.0	10.2	11.5	10.3	13.0	12.4	14.6	12.9
Private firm ownership	96.2	97.6	93.0	98.0	96.2	97.6	94.0	97.2	94.0	95.8	92.4	97.8	92.6	95.6	92.6	96.0	92.8	94.0
BELGIUM																		
Females	51.0	47.4	44.8	43.4	31.4	33.2	26.8	26.0	25.0	24.8	27.8	31.6	30.6	34.0	30.6	31.4	22.8	30.0
Years of education	10.1	10.6	10.3	10.7	10.5	11.0	10.1	11.1	10.1	11.2	10.7	11.6	11.3	12.1	12.2	12.8	12.4	13.6
Years of age	33.5	34.9	33.1	36.3	34.8	36.0	36.3	36.9	37.6	39.5	38.3	39.4	38.1	40.0	39.9	40.7	41.8	41.6
Years of job-specific tenure	4.5	4.9	5.1	6.2	6.5	6.7	7.7	7.6	8.2	8.7	8.5	8.4	8.7	9.5	9.2	9.4	10.1	8.8
Private firm ownership	98.4	96.2	97.4	92.8	98.0	96.8	97.6	97.6	97.4	95.2	97.2	95.6	96.6	95.2	96.0	97.4	97.0	98.6
Indefinite contracts	97.4	99.4	98.4	98.2	99.2	99.8	99.6	100	99.6	99.8	98.8	99.4	98.8	99.8	99.8	99.8	99.8	99.6
Full-time contracts	78.6	74.6	86.8	85.4	89.2	88.2	89.2	91.8	88.4	90.6	91.2	89.8	88.4	87.2	94.0	89.0	92.8	93.0
GERMANY																		
Females	53.0	52.2	49.6	45.4	40.0	39.2	33.8	33.0	24.2	29.0	21.6	21.6	18.4	21.8	17.6	21.0	13.6	13.4
Years of education	12.2	12.4	12.3	12.4	12.3	12.5	12.3	12.5	12.6	12.7	12.7	12.9	12.9	13.1	13.3	13.4	13.9	14.3
Years of age	38.8	39.6	38.0	39.3	39.1	39.8	38.4	39.8	39.7	40.7	39.8	42.1	40.1	41.1	41.0	42.0	42.7	44.1
Years of job-specific tenure	8.3	6.9	8.7	8.0	10.6	9.5	10.7	11.0	11.9	11.5	12.3	13.2	13.8	12.8	13.8	12.9	15.1	14.3
Private firm ownership	95.2	98.4	94.0	96.0	93.6	94.6	95.4	93.2	91.6	93.2	92.8	92.2	92.8	87.8	92.2	91.6	94.6	91.6
Indefinite contracts	98.8	93.0	98.2	93.6	99.2	95.4	99.6	97.6	99.4	98.4	100	97.0	99.4	98.0	99.6	98.0	99.8	97.0
Full-time contracts	88.0	78.4	88.6	80.8	92.8	85.6	91.6	91.4	93.4	92.8	94.0	95.8	96.6	93.8	95.0	93.6	94.2	94.4
SPAIN																		
Females	41.8	49.0	31.6	42.2	26.8	34.0	20.0	28.8	21.8	27.2	20.4	24.4	17.2	21.0	12.4	22.0	13.2	19.4
Years of education	8.2	8.3	8.2	8.4	8.1	8.6	8.6	8.8	8.7	9.4	9.1	9.8	9.5	10.5	10.0	10.8	11.4	11.8
Years of age	31.7	33.4	33.1	33.9	36.0	35.2	37.4	35.6	38.3	36.7	40.0	36.8	41.5	38.7	42.7	40.1	43.7	42.2
Years of job-specific tenure	3.9	2.7	4.9	3.8	7.3	4.1	8.5	4.8	10.2	6.9	12.1	7.6	13.8	10.1	15.5	11.9	16.2	14.9
Private firm ownership	98.0	98.2	97.2	98.6	96.2	98.2	95.4	95.0	94.8	96.8	91.4	95.4	88.4	94.8	87.4	95.8	85.6	92.4
Indefinite contracts	42.8	59.0	52.8	63.4	65.2	64.8	70.0	63.8	77.4	74.0	85.2	79.4	91.0	79.6	94.0	86.8	95.2	91.8
Full-time contracts	93.0	86.0	96.2	90.4	97.8	90.0	97.4	93.4	96.6	93.6	98.4	95.8	98.2	96.2	99.2	95.6	98.2	95.2
GREECE																		
Females	51.2	49.8	52.0	50.8	43.0	51.8	35.0	43.4	30.8	32.4	23.8	33.8	22.4	34.2	18.4	27.4	12.0	17.6
Years of education	9.8	10.5	9.7	10.7	9.9	10.8	9.8	10.7	10.4	11.1	10.4	11.6	11.3	11.8	11.4	12.3	11.6	12.9

Table A2 (cont.)

15-24 year-olds	16.6	22.8	9.2	17.8	7.0	9.8	2.6	5.2	1.4	4.0	0.8	0.4	1.0	1.2	0.2	0.4	0.2	0.8
25-34 year-olds	50.6	45.0	46.6	46.0	42.2	46.6	38.4	38.4	33.2	40.6	27.2	36.0	19.2	24.2	14.8	19.2	10.8	9.0
35-44 year-olds	20.6	18.6	23.8	22.0	28.6	25.0	33.2	34.4	41.8	30.6	42.8	35.8	45.2	41.4	43.0	40.6	36.4	33.8
45-54 year-olds	8.8	10.4	14.8	11.0	13.4	13.8	18.6	17.2	18.4	19.4	20.8	21.8	25.2	26.6	33.2	33.0	40.0	49.6
Years of job-specific tenure	4.1	2.0	5.5	3.2	7.0	4.5	8.6	5.6	10.0	6.1	11.3	8.5	13.6	11.0	15.2	13.3	16.2	16.9
Private firm ownership	85.6	94.2	88.0	95.0	81.8	94.2	74.2	91.8	70.2	88.0	61.0	82.4	51.4	72.8	52.4	66.6	50.2	68.6
HUNGARY																		
Females	54.6	36.4	51.6	50.6	46.8	49.8	46.0	50.0	46.4	42.8	39.4	37.8	34.0	42.0	37.2	38.6	39.2	34.4
Years of education	10.4	11.1	10.4	10.6	10.6	10.7	10.4	11.0	10.8	11.0	11.0	11.3	11.4	11.6	12.0	12.0	12.9	13.2
Years of age	35.2	36.6	35.9	37.0	37.2	37.9	38.2	39.9	39.4	39.4	38.9	41.0	40.5	40.4	40.5	41.8	41.9	41.4
IRELAND																		
Females	56.2	71.0	55.0	57.0	46.2	54.8	41.6	51.4	39.2	46.6	34.4	38.4	31.8	32.4	25.2	32.6	28.0	24.6
Years of education	11.0	11.4	10.7	11.4	10.8	11.6	10.9	11.7	11.0	12.1	11.2	12.1	11.7	12.8	11.9	13.3	12.6	13.4
Years of age	26.6	33.6	29.9	34.7	32.0	34.6	33.0	35.5	34.0	36.3	34.5	36.7	36.1	37.1	37.3	37.7	39.2	41.3
Years of job-specific tenure	3.0	5.5	5.1	6.7	6.6	7.0	7.9	8.2	8.6	8.7	9.0	9.6	9.5	10.0	10.8	10.7	12.9	14.1
Private firm ownership	99.4	99.8	100	99.4	99.8	98.8	99.6	99.0	97.0	96.2	95.8	95.8	95.2	94.6	94.8	89.8	91.2	81.0
Indefinite contracts	88.8	83.6	92.4	82.8	94.8	87.0	94.6	90.4	92.8	89.0	96.2	91.2	93.8	92.8	96.6	92.6	97.8	92.6
Full-time contracts	62.0	65.6	81.8	75.4	91.2	82.6	92.6	87.6	93.0	92.8	95.0	91.6	96.6	96.2	97.8	95.8	96.2	97.0
ITALY																		
Females	36.4	49.8	32.6	40.2	31.4	35.8	27.6	37.2	21.6	30.6	19.8	27.2	25.2	29.4	20.6	25.8	16.4	23.6
Years of education	8.7	9.4	8.7	9.6	8.7	10.0	9.0	10.0	8.7	10.3	9.6	10.4	10.1	10.9	10.5	11.6	11.6	12.6
Years of age	33.4	35.3	35.0	36.3	36.3	36.7	38.0	38.1	39.1	39.2	39.3	39.7	39.6	40.0	41.4	41.3	43.5	42.2
Years of job-specific tenure	5.6	6.9	7.4	8.3	9.3	8.4	10.0	11.3	12.0	12.2	11.8	11.5	12.1	12.5	13.8	13.6	15.8	13.9
Indefinite contracts	89.4	90.6	90.2	93.2	94.0	94.4	94.4	96.8	96.4	96.2	97.4	97.2	97.0	96.2	98.8	97.6	99.0	98.2
Full-time contracts	92.4	86.0	95.0	88.4	95.2	92.6	95.8	87.8	94.0	90.4	96.2	92.6	94.0	88.4	94.4	89.8	96.6	90.6
NETHERLANDS																		
Females	57.2	63.2	43.4	59.4	37.4	52.0	28.2	41.6	16.8	33.4	18.2	24.2	17.2	23.4	12.0	23.6	14.8	14.8
Years of education	11.3	10.0	11.8	10.5	11.9	10.7	11.9	11.1	11.8	11.5	12.1	12.0	12.4	12.5	13.0	13.4	14.2	14.4
Years of age	31.4	30.3	32.6	35.8	34.9	36.9	37.1	36.9	38.0	38.8	38.9	40.6	40.0	40.7	40.7	41.2	42.0	42.7
Indefinite contracts	84.8	53.2	89.8	73.4	95.0	78.0	94.6	86.6	96.6	89.6	96.8	92.0	96.8	95.2	96.4	95.8	94.6	94.8
Full-time contracts	57.4	30.2	68.4	39.4	74.4	56.8	77.4	66.6	82.4	72.4	81.0	79.4	82.0	81.0	87.6	84.2	85.8	86.6

Figure A1a. Break down of observed wage changes by country and decile, all

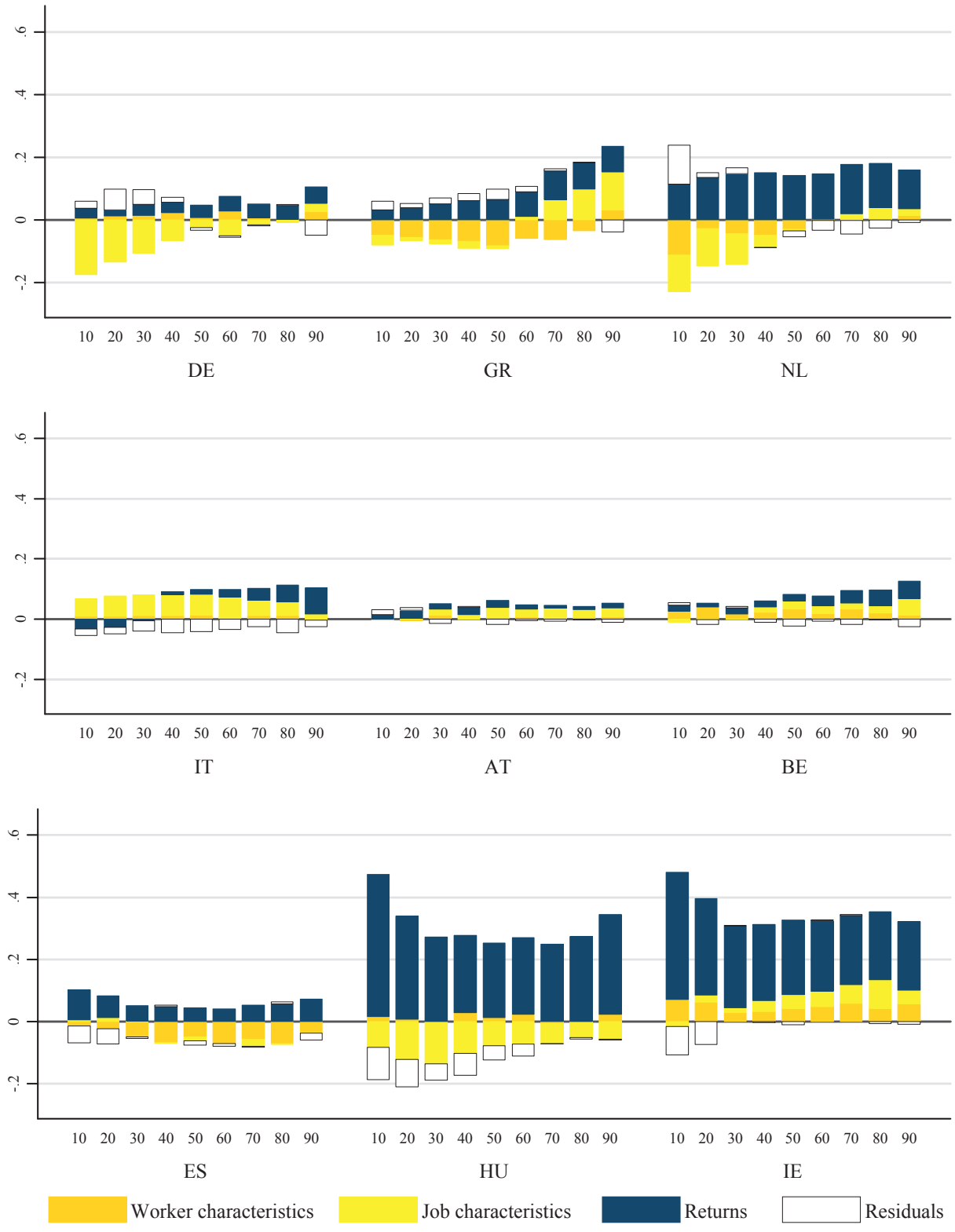

Figure A1b. Break down of observed wage changes by country and decile, males

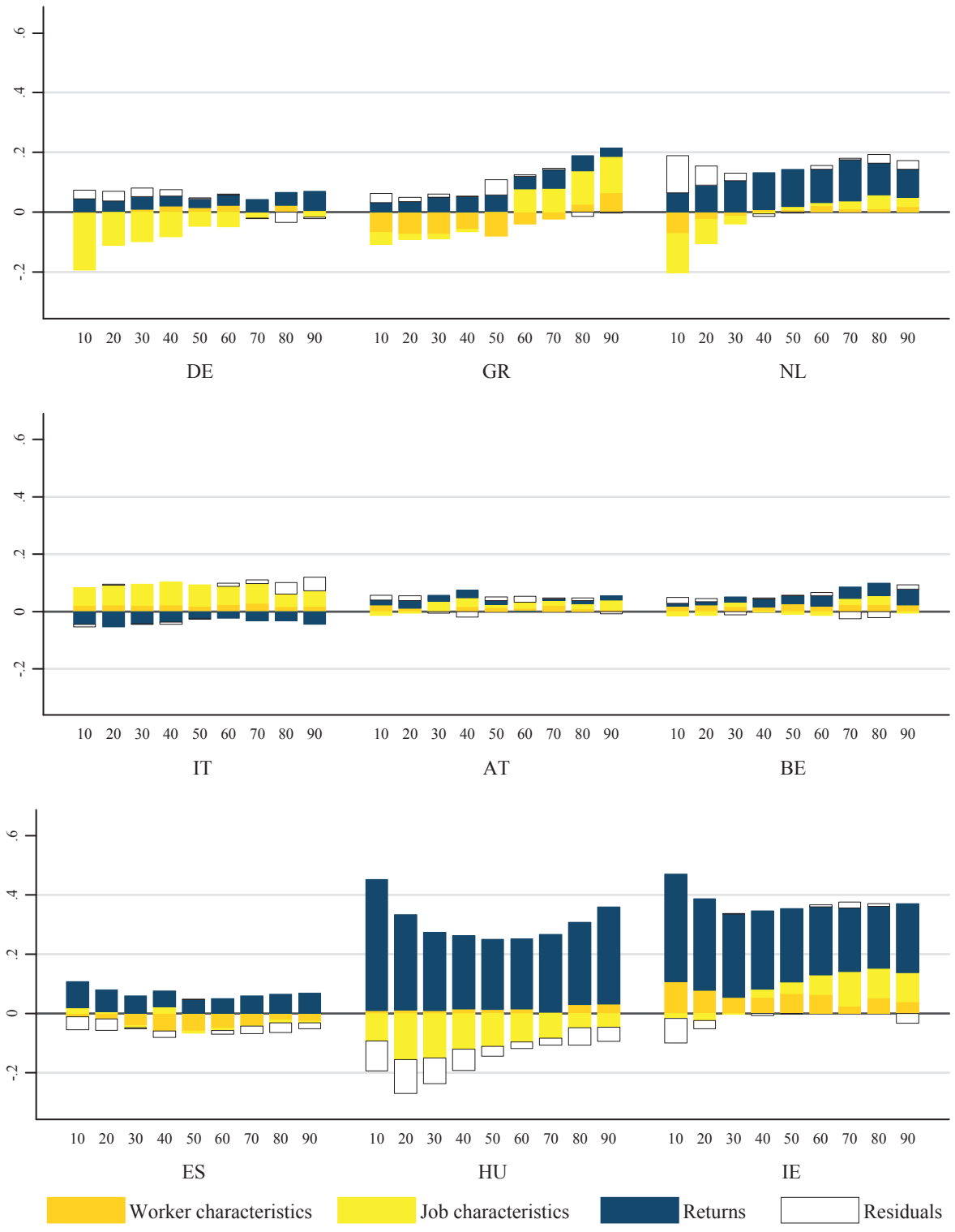

Figure A1c. Break down of observed wage changes by country and decile, females