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# Computers meet politics at wage structure: an analysis of the computer wage premium across rich countries

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## Abstract

This article addresses an important question in the age of rapid spread of new computer technologies: how do institutions influence the computer wage premium? To identify institutional factors that account for differences in computers' impact on wages, the authors estimate computer wage premiums for 20 countries classified into three national 'varieties' of capitalism and distinct forms of industrial relations and education systems. The analyses are based on unique international data from the Survey of Adult Skills, recently conducted by the Organisation for Economic Co-operation and Development. Results reveal that computer use at work is rewarded considerably higher in Liberal countries than in other countries—Nordic Coordinated countries above all. These results signify the centrality of coordinated markets, grounded in strong unions, centralized wage bargaining and publicly funded education and training, for lower computer wage gaps, hence for lower levels of wage inequality.

**Key words:** political economy, technological change, inequality, labor market institutions

**JEL classification:** P16 political economy, J5 labor–management relations, trade unions and collective bargaining, J31 wage level and structure, wage differentials

## 1. Introduction

The social science literature recognizes the key role of both computerization and political forces in the resurgence of wage inequality in rich countries since the late 1970s. Nonetheless, it leaves unsettled an important issue concerning the potential role of computers in wage determination: how can computers, which have spread across workplaces in all rich countries, explain the divergent inequality trends in Europe and the USA? There are two possible answers. One is that computerization has the same effect on inequality across countries, albeit less than the dramatic effect of neoliberal political changes manifested in union decline and deregulation of labor markets (Jacobs and Myers, 2014; Kristal and Cohen, 2017), which were particularly evident in the USA. The other underlines an interaction between institutional features and global changes that has produced different inequality outcomes. One version of this interaction, advanced by Blau and Kahn (2002), is that both Europe and the USA faced technological change. But in the USA, this found expression in reduced wages for the low skilled, whereas the rigidity of European wage-setting mechanisms minimized the impact of technological change on the wage structure, instead driving an increase in unemployment rates for the low-skilled workers. The European part of this argument, however, does not entirely fit the facts (DiPrete, 2005). Unemployment levels increased only in some European countries; the increase was not concentrated on low-skilled workers and the rise in unemployment was mainly in the 1970s and early 1980s.

Here we develop a new conceptualization of the interaction between technology and politics in the wage determination process. Like previous studies, ours contends that the effect of technological changes on wage structure was harsher in countries with a more flexible labor market such as the USA. We depart from past research by more closely considering the relation between computers and wages in different national institutional contexts. Our overall argument is that the computer wage premium, which indicates whether workers who use a computer at work earn higher wages than workers who do not, is governed by the national institutional context, fostered by class politics (cross-class alliances and inter-class conflicts), which sets wage determination norms and practices. Wage structure, employers' policies on wage determination, the scope of legitimation of workers' claims for wage increases, and the scarcity of employees able to use computers are all embedded in the institutional context. We, therefore, expect that using a computer at work will be more highly rewarded in countries where competitive markets are important sites for wage determination. Specifically, we contend that using a computer at work will be more highly rewarded in countries where industrial relations are based on weak unions and fragmented wage bargaining and in countries where there is a little public investment in education and training.

Our second contribution is, as far as we know, the first empirical analysis of the computer wage premium across rich countries and diverse national 'varieties' of capitalism. The analyses are based on unique data from the Survey of Adult Skills, developed and conducted by the Organisation for Economic Co-operation and Development (OECD) Programme for the International Assessment of Adult Competencies (PIAAC). Our analytical strategy is to utilize the rich comparative data in the PIAAC first to test the effect of computer use on labor market stratification in different institutional contexts (Liberal Market Economies (LMEs), Continental Coordinated Market Economies (CMEs), and Nordic CMEs). We further strip the common national institutional configuration down to its components by estimating how indicators for pay-setting institutions and a public-funded education system at the country-level interact with computer use to produce different wage outcomes.

In the next section, we describe findings from prior research on the computer wage premium. We have learned much about the impact of the use of a computer at work on individual earnings in specific countries, mainly from economics research, but we know surprisingly little about the effects of such inequality in different political contexts. In the following, we develop two hypotheses on how national economies' institutional configuration, particularly industrial relations and education systems, can mitigate such effects (Section 3). We then describe the PIAAC data, which enable us to study the impact of the 'computer revolution' on wage structure across countries, and our modeling strategy (Section 4). In Section 5, we present our results. To preview the main results, we find that computer use at work is rewarded considerably higher in LME countries such as the USA than in other countries—Nordic CMEs above all, even when wage structure is controlled for. These results reflect the centrality of coordinated markets, grounded in strong unions, centralized wage bargaining and public-funded education and training, for lower computer wage gaps.

## 2. Computer wage premium

Widening wage gaps between more- and less-educated workers have led many economists to argue that skill requirements rise as a result of the spread of new computer technology. Direct evidence about the effect of computer use on wage structure comes from Krueger's (1993) widely cited study, namely highly skilled workers are more likely to use computers on the job, and workers who do use computers earn 17% more than non-users, net of standard human capital variables. Krueger tried to rule out the possibility that his estimates were biased by the omission of unmeasured employee characteristics or firm attributes (i.e. firms better able to afford computers may be better able to pay higher wages). He found that the returns on computer use remained in the 10–15% range even after controlling for home computer use, two-digit occupation and industry, school grades and achievement test scores—even in homogeneous groups of workers (secretaries); his conclusion was that the observed premium for computer use reflected actual returns and not returns to other variables unmeasured.

Following Krueger's study, a debate arose as to whether the use of a computer at work indeed boosted earnings, or was this reported impact due to non-random assignment of computers to workers (i.e. employee characteristics that correlated with the provision of computers and earnings level) and non-random assignment of workers to workplaces (i.e. employers' characteristics that correlated with the provision of computers and earnings level). The general conclusion from many studies using several data sources and statistical estimation methods is that computer use exerts a causal effect on earnings. Most studies used cross-sectional data in one country and attempted to minimize the effect of observable characteristics, such as human capital, employment and sociodemographic features. They found a significant coefficient for computer use at work in ordinary least squares (OLS) regressions, which decreases as additional controls are added (Entorf, Gollac, and Kramarz, 1999; Borghans and Ter Weel, 2004; Dickerson and Green, 2004; Green *et al.*, 2007). Analysis of panel data reveals a significant but smaller effect of computer use at work on earnings (Entorf and Kramarz, 1997; Entorf *et al.*,1999; Dolton and Makepeace, 2004; DiMaggio and Bonikowski, 2008).

Findings from two recent studies are particularly significant in establishing that the use of a computer at work indeed boosts earnings. Spitz-Oener (2008) used a more recent wave—1998–1999—of the same cross-sectional data as DiNardo and Pischke (1997) and found that the return on computer use was robust, but the return on pencil use had disappeared. Utilizing the 2004 Workplace Employment Relations Survey employer–employee matched sample, Dolton and Pelkonen (2008) found a computer wage premium within the UK establishments of 12.7% and 2.8% within establishments and detailed occupations.

Utilizing propensity-score matching techniques to address sample-selection bias, based on observable characteristics of computer users and non-users, revealed a significant computer-use effect on wages in both studies (Dolton and Pelkonen, 2008; Spitz-Oener, 2008).

Clearly then, workers who use computers at work earn more, but there is much debate about why. The leading argument here, put forward by economists, advocates a productivity-enhancing mechanism. Krueger (1993) argues that employees who use a computer at work earn more because they are being rewarded for their computer-specific skills, which enhance their productivity. More recently it was argued that the computer wage premium is a return on computer-specific skills, but also on general cognitive skills such as problem-solving, which are associated with computer use and enable performance of non-routine cognitive tasks at work (Autor *et al.*, 2003; Spitz-Oener, 2006, 2008). All these researchers contend that new technologies increase demand for highly skilled workers, thereby increasing their earnings. This theory, called Skill-Biased Technology Change, still lies at the heart of our understanding the relationship between technology and wages: the more technologically skilled a worker is, the more attractive he/she will become to employers, hence increasing his/her wages.

Another plausible explanation elucidates why using a computer at work yields a higher wage, implying a non-productivity-related status distinction. DiMaggio and Bonikowski (2008) elaborate two more mechanisms whereby workers may gain earnings advantages by using new technology beyond the workplace as well. First, using Internet at home contributes to earnings by signaling status or competence. Secondly, the use of Internet contributes to earnings by facilitating access to labor market information, through expansion and easier exploitation of social networks. These two mechanisms can also help explain why workers gain earnings advantage by using a computer at work. Workers who know how to use the computer may be seen by employers—but not necessarily are—as more competent and intelligent, and also can gain privileged access to workplace-specific information. Thus using a computer at work can generate resources that workers can use in making claims on starting salary and pay raises. Greater bargaining power at the workplace (Wright, 1979) and more generally in the labor market (Kalleberg *et al.*, 1981) often results in higher pay.

Earlier research established that using a computer at work increases workers' earnings not only in the USA (Krueger, 1993), but also in France (Entorf and Kramarz, 1997; Entorf *et al.*, 1999), Germany (DiNardo and Pischke, 1997; Spitz-Oener, 2008), Italy (Di Pietro, 2007) and the UK (Dickerson and Green, 2004; Dolton and Makepeace, 2004; Green *et al.*, 2007; Dolton and Pelkonen, 2008). Since previous studies used different data and a different research design, we do not know whether the computer wage premium varies across countries. But two main reasons may lead us to expect that it should. First, the computer wage premium is related to wage inequality (Krueger, 1993), and comparative studies have demonstrated that the higher wage inequality in the USA can be explained by higher returns on education (Freeman and Schettkat, 2001; Blau and Kahn, 2005) and cognitive performance (Blau and Kahn, 2005; Carbonaro, 2006; Hanushek *et al.*, 2013). Therefore, different wage inequality levels across countries may also be explained by different returns on computer use. Even more importantly, as we elaborate below, several institutional features have proved active in wage inequality across countries (Esping-Andersen, 1990; Hall and Soskice, 2001), so we can theorize that institutions too create variance across countries in the computer wage premium.

## 3. How can national institutions mitigate computers' effect on wage structure?

To better understand computers' impact on the wage structure across countries, we advance a new perspective that underlines the interactions between technology and politics in the wage determination process. Our general argument is that using a computer at work should be more highly rewarded in countries where competitive markets are important sites for wage determination. To find out in which countries competitive markets are important sites for wage determination, we draw on comparative political economy literature. This field encompasses several analytical frameworks with common concern to understand the institutional foundations of diverse national 'varieties' of capitalism, mostly focusing on institutional diversity at the national level (or at the level of families of nations). These frameworks frequently serve in efforts to compare how institutional diversity affects aggregate economic performance outcomes across advanced industrial countries, on the assumption that national economies are characterized by distinct institutional configurations that shape the behavior of economic factors such as employees, business firms and shareholders (Jackson and Deeg, 2006). Central to this literature, based on the 'Varieties of Capitalism' (VoC) agenda, is examining institutional variation across developed economies by focusing on differences in the social organization of private economic activity (Hall and Soskice, 2001). This means that the VoC approach rests on the assumption that in the economy the central actors are firms whose behavior aggregates into national economic performance.

We find the VoC firm-centered political economy framework a useful guide in developing hypotheses on how and why countries differ on the computer wage premium. It is because the VoC approach emphasizes business firms' embeddedness in social contexts, and differences in the social organization and governance of firms in different economies—all very relevant for understanding the impact of technological change on wage structure across countries. This firm-centered political economy approach and a labor-centered approach (i.e. neo-corporatism, welfare regimes) do evince important differences (Korpi, 2006; Iversen and Soskice, 2009); nevertheless, the more recent VoC classifications of countries into LMEs, Continental CMEs or Nordic CMEs (explained below) are closely consistent with the literature on national labor movements. This is because of the mutually reinforcing relations among labor's strength, skill formation and education system (Iversen and Stephens, 2008); the first has been vital for a labor-centered approach and the other two for a firm-centered approach. Therefore, in developing our argument we integrate claims from the labor-centered political economy approach (Korpi, 1983; Esping-Andersen, 1990), as unions have a pivotal role in mediating technological change (Fernandez, 2001). Throughout this article, we use the VoC terms for groups of countries, since classifications of countries according to the organizational strength of the working class are closely correlated with the more recent VoC classification.

The VoC firm-centered political economy approach contrasts two basic ideal types of capitalism. In LMEs, such as the USA, the UK or Canada, the competitive market dominates in coordinating economic behavior. The strategic behavior of firms[1] in the coordination of

1 Not all firms in a country act alike. Rather, the logic is that 'in any national economy, firms will gravitate toward the mode of coordination for which there is institutional support' (Hall and Soskice, 2001, p. 9).

the economy is usually determined by supply-and-demand conditions, relative prices and market signals in competitive markets. In CMEs, such as Germany, Sweden or Japan, economic behavior is strategically coordinated more through non-market mechanisms. Firms typically engage in more strategic interactions with trade unions and other actors, generating a more egalitarian variety of capitalism. As a result, income inequality in LMEs is intrinsically higher than inequality in CMEs (Rueda and Pontusson, 2000; Hall and Soskice, 2001).

Based on the comparative political economy literature, we first expect to find variance among countries in wage returns on computer use, indicating institutional factors that widen these differences among countries in the computer wage premium. Going a step farther, we expect to find a general pattern in which diverse national 'varieties' of capitalism differ in the computer wage premium. This may be largely related to whether competitive markets are important sites for wage determination. In countries where wages are coordinated more through non-market mechanisms, the effect of computer use (via worker's skills or bargaining power) on worker's wages should be moderated more than in countries where the competitive market dominates the wage determination process. In other words, the computer wage premium should be lower in CMEs than in LMEs.

We expect CME countries to differ in the computer wage premium. New market pressures and the attendant ascendance of a neoliberal ideology have led some researchers to argue for a convergence to one variety of liberal capitalism, and others to stress the formal institutional stability in CMEs. In between, Thelen (2014) unpacks the rather diverse logics behind alternative modes of coordination by analytically differentiating two 'varieties of liberalization' in CMEs. 'Dualizing liberalization', which is associated with conservative Christian Democratic countries such as Germany, involves ongoing strong coordination on the employer's part (mostly organized around manufacturing interests) but a decline in collective bargaining coverage, a more marginal role for semi-skilled workers in industry unions, and an increase in the number of irregular workers employed in more precarious forms of employment. Another trajectory of liberalization, associated with Scandinavian Social Democratic countries such as Denmark and termed by Thelen 'embedded flexibilization', involves the introduction of new forms of flexibility to adapt workers' skills to changing market conditions in the context of a continued strong and encompassing framework that collectivizes risk. Although an employer-coordinated bargaining structure is not meant directly to minimize computers' impact on the wage structure, the collective, centralized and coordinated bargaining that characterized Nordic CMEs diminishes the role of workers' supply and demand, as well as individuals' bargaining power in wage determination. Therefore, the institutional structure of Nordic CMEs should be associated with a lower computer wage premium than the institutional structure of Continental CMEs.

To better identify particular institutions that matter for the computer wage premium, our main arguments strip national institutional configuration down to its components by focusing on the effect of wage-setting institutions and the education and training system on computer wage gaps.[2] Besides these two institutions, the VoC literature examines further institutional domains such as the financial systems, corporate governance and the institutional linkages that give rise to specific configurations of capitalism; we, however, find that a focus on the two particular institutions 'wage-setting institutions' and the 'education and

2 Single-variable thinking is quite different from configurational thinking, but they may usefully inform one another (Jackson and Deeg, 2008).

training system' is valuable for a deeper understanding of how institutional contingencies matter for what seems a universal technological trend.

We know from previous studies that collective bargaining, especially where it covers most or all wage earners and is centralized, squeezes the distribution of earnings relative to market pay-setting (Iversen, 1999; Wallerstein, 1999; Rueda and Pontusson, 2000; Kristal and Cohen, 2007; Visser and Checchi, 2009). But does extensive and centralized collective bargaining also reduce the computer wage premium? We argue that it does. Dominant labor unions that establish widespread bargaining coverage can stimulate practices and norms of equity across workplaces, and mute thereby the upward pressure of high-wage workers who use a computer at work for pay rises. Centralized wage bargaining at the sector level or nation-wide also contributes to harmonizing pay across workplaces as it typically endorses the principle of 'equal pay for equal work' (i.e. equal hourly pay for similar jobs, the worker's characteristics notwithstanding) that put a limit on wage rises of members who work in the most profitable workplaces (Iversen, 1999; Visser and Checchi, 2009). Also, within workplaces centralized wage bargaining contributes to harmonizing pay by leveling earning differentials related to skill, education and status (Tomaskovic-Devey *et al.*, 2009; Heinze and Wolf, 2010), and reducing the overall effect of establishments' investments in computers on within-establishment inequality (King *et al.*, 2017). We, therefore, expect countries' wage-setting institutions to mitigate the computer wage premium thus:

*Hypothesis 1: The computer wage premium will be highest in countries where industrial relations are based on weak unions and fragmented wage bargaining, and lowest in countries where industrial relations are based on strong unions and centralized wage bargaining.*

The scarcity of employees able to use computers in the respective country should also lead to a higher computer wage premium. The latter circumstance is mainly affected by the education and training system that goes hand in hand with the strength of the labor movement (Iversen and Stephens, 2008; Busemeyer and Iversen, 2012). Typically, LME countries are associated with highly stratified systems of vocational education and training (VET) organized around the inculcation of general skills that often reflect and reinforce economic inequalities. By contrast, CMEs feature stronger systems of VET organized around firm- or industry-specific skills that offer opportunities for working-class youth to move into stable and relatively well-paid jobs (Estevez-Abe *et al.*, 2001; Thelen, 2004; Busemeyer and Trampusch, 2012).[3] Most importantly, in CMEs, employers—for rational, functional or political reasons—coordinate to secure a highly skilled workforce well trained to meet new job requirements due to technological change. Different structures of education and training systems should result in variation among countries in scarcity of employees able to use computers. In turn, a higher share of workers who use computers at work should play out in a lower return on computer use, because of market forces' mechanisms (i.e. high supply) or relative bargaining power (i.e. more similarity in bargaining).

3 The two ideal types of skill formation systems are firmly connected to labor market policies. In CMEs, these feature stronger employment protection and associated longer job tenures, whereas LMEs are characterized by fluid labor market regimes and weak to no employment protection regulations that provide workers with greater opportunities to move their resources around in search of higher returns.

We expect to find the highest level of computer users, hence the lowest level of computer wage premium, in countries characterized by heavy investment in public education and industry- and occupation-specific vocational skills. This form of education and training system, as Iversen and Stephens (2008) show for literacy skill, fosters high levels of human capital (skills both specific and general such as literacy, math and information technology knowledge), especially at the bottom of the skills distribution. By contrast, in countries with low investment in public education and training, we expect to find the lowest level of computer users—particularly among low-wage workers—hence the highest level of computer wage premium.

*Hypothesis 2: The computer wage premium will be highest in countries with little investment in public education and training, and lowest in countries with heavy investment in public education and industry-specific and occupation-specific vocational skills.*

## 4. Data and methods

To determine whether the effect of computers on wages varies among countries, we analyze new international data on adult skills by means of the so-called PIAAC. The Survey of Adult Skills, conducted under the auspices of the OECD in 2011–2012 for 24 countries, and in 2014–2015 for an additional 9 countries, provides comparable data on workers' skills, demographic characteristics, education, employment, use of computers (at work and at home) and earnings, for a representative sample of adults in 33 countries (sample size is about 5000 in each country). We restricted the analyses to employed wage and salary workers aged 20–65 years; this reduced sample size to about 3000 per country yields a total of 72 155 observations in the pooled sample. Countries' sample sizes are shown in Appendix A.

We focus on 20 rich countries: Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Ireland, Israel, Italy, Japan, Korea, the Netherlands, New Zealand, Norway, Spain, Sweden, the UK and the USA (only Israel and New Zealand participated in the second round in 2014–2015). Public Use Files containing individual data can be downloaded at the OECD website for each participant country except Australia,[4] for which we obtained the PIAAC data directly from the Australian Bureau of Statistics. In the Public Use Files, earnings data for Austria, Canada, Germany, Sweden and the USA are reported only in deciles. For Germany, we obtained the German PIAAC Scientific Use File, which contains earnings as a continuous variable, from the German Social Science Infrastructure Services–Leibniz-Institute for the Social Sciences. For Austria, Canada, Sweden and the USA, we analyzed models only for wage deciles.

### 4.1 Individual-level variables

The dependent variable in the analysis, namely hourly earnings, is defined once in nominal terms and again in standardized terms to differentiate wage structure from other institutional effects. The *nominal* measure is expressed in terms of the logarithmic transformation of gross hourly earnings including bonuses, corrected by purchasing power parity and converted into US dollars by the OECD. Gross pay is defined as pay before deductions for tax and national insurance (social security contributions), including any regular overtime pay,

4 We use the updated public-use files released on June 28, 2016.

regular bonuses, tips and commissions, excluding annual bonuses. In each country, we trimmed the bottom and top half of a percent of the wage distribution to limit the influence of outliers. The *standardized* measure is a decile ranking scale on which individuals in each country are ranked according to their relative earnings on a standardized (decile) earnings ladder. Being sensitive to relative ranks rather than the absolute wage, wage deciles use eliminates cross-national differences on the level of overall wage inequality.

The unique quality of the PIAAC data allows us to analyze the computer wage premium across rich countries. Our key independent variable is *computer use at work*. It is a dummy variable based on the survey question 'Do you use a computer in your job?' Computer is broadly defined, covering a mainframe, desktop or laptop computer or any other device that can be used to do such things as send or receive email messages, process data or text, or find things on the Internet.

To estimate the effect of computer use on workers' wages, we divided the independent variables into three groups (see Appendix A). The first group is introduced into the equations to control for cross-national differences in the composition of wage-determining characteristics. These variables are uniformly recoded as follows: gender (men coded 1),[5] immigrant status (native-born and second-generation immigrants, coded 1), three educational measures (primary, secondary and high),[6] work experience (years of paid work over a lifetime),[7] full-time status (at least 30 h a week), type of contract (contracts of unlimited duration, coded 1, and contracts of limited duration, coded 0), workplace tenure and sector (public sector, coded 1). Unlike traditional income surveys that generally do not provide information on employers, the PIAAC data allow taking two company characteristics into account: large firm (more than 250 employees, coded 1) and whether the place of work is part of a larger organization.

Computer use may be associated with other characteristics that are usually unobserved but are causally related to wages, yielding regression coefficients that partly reflect the unobservable effects of computers on wages in addition to the true effects. The second type of variables is therefore introduced into the analysis to control for job features, including a set of four occupational measures (skilled, semi-skilled white collar, semi-skilled blue collar and elementary), a dummy indicating whether the respondent works in the manufacturing sector, and a dummy variable, coded 1, for workers who report that they manage or supervise other employees. As controls for jobs' features are added, the likelihood that the computers effect is determined purely by unobserved ability differences decreases.

The third type of independent variables enables testing hypotheses on the mechanisms whereby computer use affects earnings by including in the models rather scarce indicators of workers' cognitive skills and computer-specific skills. We measured workers' cognitive and computer-specific proficiency by respondents' scores on numeracy and 'problem-solving in technology-rich environments' tasks.[8] Measurements for numeracy and computer-specific

5 There is no information on marital status in the survey, and too many values are missing from the nearest variable for living together, which precludes using it in the models.

6 High education is short-cycle tertiary education, a Bachelor's degree (or equivalent) and higher degrees.

7 The experience measure refers to actual work experience. It was collected as the number of years in which at least 6 months were spent in paid work.

8 The size of the population for which proficiency scores for problem-solving are not reported, varied across countries. In our sample the proportion ranged from below 10% (the Netherlands, New

proficiency are on 500-point scales that describe gradations in the complexity of the tasks. The score domains are not very closely correlated with an individual-level correlation between numeracy and computer-specific skills of 0.801, making it possible to distinguish different skills. For analytical purposes, we standardized scores in the following regression analyses to set a within-country mean of zero and a within-country standard deviation of 1. Since our skill measure was standardized to (0, 1), the coefficient can be interpreted as the percentage increase in wage associated with a 1 SD increase in measured skills.

Because the PIAAC was designed to provide accurate estimates of proficiency in the two domains across the adult population and its major subgroups, rather than at the level of individuals, each respondent was given a subset of the test items used in the numeric and computer assessment. The OECD imputed proficiency scores for each respondent based on performance on test items and background characteristics. The uncertainty of imputation is reflected in 10 plausible values for each respondent on the scales for cognitive and computer proficiency. When we included numeracy or computer-specific skills as independent variables, we calculated the coefficient by estimating a model for each possible value, and then averaged the results. The standard errors were computed by calculating the square root of the overall variance of estimate.

### 4.2 Country-level variables

To estimate whether and how specific national institutions mitigate the returns on computer use, we utilize several indicators for pay-setting institutions and education systems at the country level (Table 3). Many problems beset specifying the best variables and their measurement representing countries' bargaining behavior that is also comparable across countries (Kenworthy, 2001; Traxler *et al.*, 2001). Recently, Jelle Visser (2016) presented new harmonized measures of bargaining coverage and the structure of bargaining based on an updated version of the database on Institutional Characteristics of Trade Unions, Wage Setting, State Intervention and Social Pacts. Here we use three specific measures for pay-setting institutions. First, *bargaining coverage* indicates the degree of collective organization in the labor market. It denotes the proportion of employees or wage earners to whom a collective agreement signed by a union or worker representative and the employer or employers' association applies. High bargaining coverage is typically based on the combination of three institutional variables: sector (or national) bargaining; a high level of employer organization; a frequent, though not necessarily 'automatic', use of administrative extension of agreements.

We also employ two indicators for the bargaining structure. The *level of wage bargaining* indicates if the locus of decision-making over wages is closer to the sector or to the individual enterprise. *Bargaining centralization* more broadly encompasses the structure of collective bargaining as it takes into account union authority and union concentration at multiple

Zealand, Norway and Sweden) to above 20% (Australia, Korea, Ireland, Israel and Japan), with the other countries in between. Excluding them from the analysis could bias our results, because a computer-related non-response would probably be related to lower computer skills. We therefore included non-responses in the analysis. Since the non-responsive seem more similar to the respondents with no computer skills than to those who took the computer-based assessment, we decided to impute to a non-response the minimum value in the computer-specific skill measure. The conclusions remain the same in models that do not include individuals who opted out of the problem-solving test.

levels (derived from Iversen's centralization index). Bargaining centralization is highly correlated with union centralization, which some analysts consider a dimension of union strength since it facilitates unified action. As shown in Table 3, there is a remarkable difference in bargaining coverage between LME countries and CME countries, but CME countries show hardly any differences among European countries (except Germany, where coverage declined after the unification of East and West Germany in 1990), some differences in bargaining structure notwithstanding.

To study whether and how countries' education systems interact with computer use at work to produce different stratification outcomes we employ two common indicators for the education and training system, based on an OECD (2017) publication. The first is *public education spending as a percentage of gross domestic product (GDP)*; the second is *public investment in vocational training* (the correlation between the two is 0.60). The latter is measured by public spending as a percentage of GDP on upper secondary education multiplied by share of upper secondary students in vocational programs (both school and dual training schemes). Countries with extensive school-based VET (Scandinavian countries, France, Belgium) score high on this measure, as do countries with strong apprenticeship training systems (Germany, Austria, Switzerland and Denmark). By contrast, countries with low levels of public investment in vocational training with slight firm involvement (i.e. Liberal countries) score low on this measure, while in between are other countries, particularly southern European (Italy and Spain), characterized by a medium level of public investment on vocational training with slight firm involvement.

### 4.3. Analytic strategy

Our first analyses predict the premium for using a computer at work on hourly earnings in different institutional settings. That is, within each country (Table 3), or group of countries (Tables 1 and 2), we estimate whether workers who use a computer at work earn higher wages than workers who do not. To describe how computers' effect on wage structure differs across countries and across distinct institutional configurations, we analyze the interaction between computer use and the three main diverse national 'varieties' of capitalism, using OLS regressions on wage samples pooled across countries with cluster-robust standard errors. When the latter are utilized, individual observations in our data become clustered within countries, therefore they are not independent.[9] In this first analysis, we classify the 20 rich countries in our sample as the three stylized ideal types according to recent comparative political economy literature (Iversen and Stephens, 2008; Thelen, 2014). LME countries are Australia, Canada, Ireland, Israel,[10] New Zealand, the UK and the USA; Continental CMEs are Austria, Belgium, France, Germany, Italy, Japan, Korea, the Netherlands and Spain; and

9 This method of analysis yields correct point estimates, but due to the small number of clusters (20 countries) it may yield confidence intervals that are too narrow. We utilized a user-written Stata program called 'clustse' which implements some options for estimating the statistical significance of parameters when the data are grouped in a small number of clusters. Conclusions were unchanged in these models.

10 Around the mid-1980s, Israel's political economy transformed from a variant of coordinated capitalism as in much of northern Europe to a much more liberal capitalism as in Anglo-Saxon countries (see Paz-Fuchs *et al.*, 2018).

**Table 1.** OLS regression estimates of the effect of computer use on nominal wage in LMEs, Continental CMEs and Nordic CMEs, 2011–2015

| Dependent variable | Ln Hourly Wage | | | | |
|---|---|---|---|---|---|
| | Model 1 | Model 2 | Model 3 | Model 4 | Model 5 |
| Computer use at work | 0.265*** | 0.168*** | 0.139*** | 0.138*** | 0.109*** |
| | (0.012) | (0.012) | (0.012) | (0.012) | (0.015) |
| Continental CMEs × Computer | −0.050*** | −0.026 | −0.005 | 0.000 | 0.018 |
| | (0.014) | (0.014) | (0.014) | (0.014) | (0.019) |
| Nordic CMEs × Computer | −0.162*** | −0.156*** | −0.123*** | −0.142*** | −0.136*** |
| | (0.014) | (0.013) | (0.013) | (0.016) | (0.017) |
| General cognitive skills | – | – | – | – | 0.001*** |
| | | | | | (0.000) |
| Computer-specific skills† | – | – | – | – | 0.000 |
| | | | | | (0.000) |
| 4 occupation dummies, managers, manufacturing | No | Yes | No | No | No |
| 9 one-digit occupation dummies | No | No | Yes | No | Yes |
| 9 one-digit industry dummies | No | No | Yes | No | Yes |
| 48 two-digit occupation dummies‡ | No | No | No | Yes | No |
| 21 two-digit industry dummies‡ | No | No | No | Yes | No |
| $R^2$ | 0.364 | 0.415 | 0.433 | 0.444 | 0.450 |
| $N$ | 49 140 | 49 140 | 48 738 | 45 607 | 34 835 |

*Source:* Authors' calculations of the PIAAC.

*Notes:* The analysis covers wage and salary workers aged 20–65 years. Sample weights are applied. The coefficients are followed by robust standard errors in parentheses. Control variables are omitted for parsimony. The controls in Models 1–5 are gender, native born, education, work experience, work experience, $^2$full time, type of contract, tenure, sector, large firm and part of larger organization.

LMEs are Australia, Ireland, Israel, New Zealand and the UK. Continental CMEs are Belgium, France, Germany, Italy, Japan, Korea, the Netherlands and Spain. Nordic CMEs are Denmark, Finland and Norway.

†Data are unavailable for Italy, France and Spain.

‡Data are unavailable for Finland.

***$P < 0.001$.

Nordic CMEs are Denmark, Finland, Norway and Sweden.[11] This recent VoC classification is identical to rival institutional-related categorization in the list of countries in each category (LME is identical to the liberal regime, Continental CMEs to the corporatist regime and Nordic CMEs to the social democratic regime).

To test our main hypotheses regarding how countries differ in computers' effect on wage structure according to their wage-setting and training systems, we analyze hierarchical linear models that facilitate estimating country-level effects on wages while controlling for cross-country differences in the composition of the individuals nested in them. We estimate a random intercept and a random slope hierarchical model to predict logged hourly wages. The two-level model can be represented by a set of equations:

11 We decided to include France, Italy and Spain in the Continental CME category although their institutional setting is more ambiguous and may constitute a Mediterranean cluster. This is because the main institutional difference is in the sphere of corporate finance, which we consider less relevant for computers' impact on the wage structure.

**Table 2.** OLS regression estimates of the effect of computer use on standardized wage in LMEs, Continental CMEs and Nordic CMEs, 2011–2015

| Dependent variable | Hourly wage deciles | | | | |
|---|---|---|---|---|---|
| | Model 1 | Model 2 | Model 3 | Model 4 | Model 5 |
| Computer use at work | 1.312*** | 0.826*** | 0.772*** | 0.755*** | 0.534*** |
| | (0.081) | (0.080) | (0.080) | (0.090) | (0.089) |
| Continental CMEs × Computer | −0.176 | −0.095 | −0.064 | −0.045 | 0.157 |
| | (0.100) | (0.097) | (0.094) | (0.098) | (0.098) |
| Nordic CMEs × Computer | −0.344*** | −0.384*** | −0.243** | −0.381*** | −0.176 |
| | (0.103) | (0.099) | (0.093) | (0.100) | (0.099) |
| General cognitive skills | – | – | – | – | 0.006*** |
| | | | | | (0.001) |
| Computer-specific skills† | – | – | – | – | 0.002 |
| | | | | | (0.001) |
| 4 occupation dummies, managers, manufacturing | No | Yes | No | No | No |
| 9 one-digit occupation dummies | No | No | Yes | No | Yes |
| 9 one-digit industry dummies | No | No | Yes | No | Yes |
| 48 two-digit occupation dummies‡ | No | No | No | Yes | No |
| 21 two-digit industry dummies‡ | No | No | No | Yes | No |
| $R^2$ | 0.381 | 0.442 | 0.460 | 0.477 | 0.481 |
| $N$ | 72 185 | 72 185 | 71 401 | 51 033 | 54 152 |

*Source:* Authors' calculations of the PIAAC.

*Notes:* The analysis covers wage and salary workers aged 20–65 years. Sample weights are applied. The coefficients are followed by robust standard errors in parentheses. Control variables are omitted for parsimony. The controls in Models 1–5 are gender, native born, education, work experience, work experience, $^2$full time, type of contract, tenure, sector, large firm and part of larger organization. For Canada and the USA, the type of contract is imputed at the LME level.

LMEs include are Australia, Canada, Ireland, Israel, New Zealand, the UK and the USA. Continental CMEs are Austria, Belgium, France, Germany, Italy, Japan, Korea, the Netherlands and Spain. Nordic CMEs are Denmark, Finland, Norway and Sweden.

†Data are unavailable for Italy, France and Spain.

‡Data are unavailable for Austria, Canada and Finland.

$^{***}P < 0.001$.

$$(\text{earnings})_{ij} = \beta_{oj} + \beta_{1j}(\text{computer use})_{ij} + \beta_n X_{ij} + \varepsilon_{ij} \quad (1)$$

At the individual level, the dependent variable is the logarithmic transformation of gross hourly earnings of individual $i$ in country $j$, and $\beta_{oj}$ is the intercept denoting the average earnings. 'Computer use' denotes whether the employee uses a computer at work (coded 1) or not (coded 0), and its coefficient $\beta_{1j}$ represents the average computer wage premium. The vector $X_{ij}$ denotes other individual-level explanatory variables, $\beta_n$ denotes their coefficients, and $\varepsilon_{ij}$ is the error term. This equation allows the intercept $\beta_{oj}$ and the computer effect $\beta_{1j}$ to vary across countries (i.e. to be random) while the effects of all other variables are constrained to be the same across countries (i.e. to be fixed). At the second level, country-level

**Table 3.** Computer wage premium (2011–2015) and national institutional context (2012–2014) by country

| | Computer wage premium | | National institutional context | | | | |
|---|---|---|---|---|---|---|---|
| | Computer wage premium—nominal wage | Computer wage premium—Standardized Wage | Bargaining coverage rate | Level of wage bargaining | Bargaining centralization | Public education spending | Public investment in vocational training |
| LME countries | | | | | | | |
| Australia | 0.176 | 1.124 | 60 | 2 | 0.517 | 3.9 | 40.6 |
| Canada | – | 1.220 | 29 | 1 | 0.303 | 4.5 | 10.4 |
| Ireland | 0.220 | 1.152 | 40 | 1 | 0.462 | 4.4 | 35.8 |
| Israel | 0.244 | 1.390 | 26 | 2 | NA | 4.7 | 69.7 |
| New Zealand | 0.233 | 1.683 | 15 | 1 | 0.305 | 4.7 | 38.4 |
| UK | 0.252 | 1.549 | 29 | 1 | 0.113 | 4.8 | 56.0 |
| USA | – | 1.144 | 12 | 1 | 0.182 | 4.2 | NA |
| Continental CMEs countries | | | | | | | |
| Austria | – | 1.332 | 98 | 3 | 0.875 | 4.7 | 70.0 |
| Belgium | 0.178 | 1.466 | 96 | 5 | 0.478 | 5.6 | 108.0 |
| Germany | 0.211 | 1.181 | 58 | 3 | 0.470 | 3.7 | 37.6 |
| France | 0.129 | 1.039 | 98 | 3 | 0.235 | 4.8 | 49.2 |
| Italy | 0.152 | 0.976 | 80 | 3 | 0.378 | 3.6 | 61.6 |
| Japan | 0.203 | 1.150 | 18 | 1 | 0.317 | 3.2 | 16.1 |
| Korea | 0.204 | 0.930 | 12 | 1 | NA | 4.6 | 18.0 |
| The Netherlands | 0.238 | 1.604 | 84 | 3 | 0.571 | 4.5 | 62.1 |
| Spain | 0.158 | 0.894 | 78 | 3 | 0.377 | 3.5 | 28.0 |
| Nordic CMEs countries | | | | | | | |
| Denmark | 0.114 | 0.970 | 84 | 3 | 0.417 | 6.3 | 58.8 |
| Finland | 0.147 | 1.164 | 90 | 4 | 0.434 | 5.6 | 106.5 |
| Norway | 0.105 | 0.912 | 67 | 3 | 0.508 | 6.1 | 75.0 |
| Sweden | – | 0.875 | 89 | 3 | 0.523 | 5.2 | 41.8 |

*Source*: Computer wage premium is based on authors' calculations of the PIAAC.

Data on bargaining coverage rate and on centralization of wage bargaining are from Visser (2016). Level of wage bargaining: 1 = bargaining is predominantly at the local or company level, 2 = intermediate or alternating between sector and company bargaining, 3 = bargaining is predominantly at the sector or industry level, 4 = intermediate or alternating between central and industry bargaining, 5 = bargaining is predominantly at the central or cross-industry level and there are centrally determined binding norms or ceilings to be respected by agreements negotiated at lower levels. Data on public education spending are from OECD (2017). Public investment in vocational training is measured by public spending as percentage of GDP on upper secondary education multiplied by share of upper secondary students in vocational programs (both school and dual training schemes).

characteristics (in this case wage-setting and education systems) explain these random effects, as presented in Equations (2) and (3):

$$\beta_{oj} = \gamma_{00} + \gamma_0(\text{country} - \text{level characteristics})_j + \mu_{0j} \quad (2)$$

$$\beta_{1j} = \gamma_{10} + \gamma_1(\text{country} - \text{level characteristics})_j + \mu_{1j} \quad (3)$$

Our main interest is Equation (3), which represents the interaction between computer use and country-level characteristics on earnings. The dependent variable $\beta_{1j}$ denotes the average earnings gap between those who use a computer at work and those who do not, in each country, while country-level characteristics (in this case wage-setting and training systems) are introduced to explain this variation across countries. All three equations are estimated simultaneously.

In all the PIAAC's country samples, complex sample designs were used. Analyzing the data requires the use of special methods developed to obtain correct results. These methods cannot be used directly in available statistical packages. Usefully, the OECD PIAAC team developed several user-written commands in the Stata® programming language to obtain correct estimates of basic statistics and to facilitate a regression analysis with the PIAAC.[12] When calculating the two-level hierarchical models, sampling weights used on the Level 1 unit are rescaled to reduce bias in variance parameter estimators (see Rabe-Hesketh and Skrondal, 2006).

## 5. Results

### 5.1 Cross-national variability in returns on computer use

The results presented in Table 1 are aimed to establish the following: whether LMEs, Continental CMEs and Nordic CMEs differ in the effects of computer use on nominal wages. In the first specification of Table 1 (Model 1) we control for gender, immigrant status, three educational measures (primary, secondary and high), work experience, work experience squared, full-time status, type of contract, workplace tenure, sector, large firm and part of a larger organization (full results are presented in Appendix B). This equation specification is the closest to Krueger (1993) and most of the literature, in the sense that it does not control for occupation or industry, nor does it distinguish the different things workers do with a computer at work. In additional specifications, we control for heterogeneity effects at the occupational level and industrial sector level (Models 2–4), and for cognitive and computer-specific skills (Model 5).

Table 1 shows first that the effect of computers on wages is substantial. According to the extended table in Appendix B, the effect of computers on wages is already second in size to education (workers with high education earn 31% higher pay than workers with primary education, and 19.8% higher pay when occupation and industry are controlled for: see Appendix B). Looking at differences among LMEs, Continental CMEs and Nordic CMEs in the computer wage premium, we find—consistent with our expectation—that CMEs moderate the effect of computers on wages, and that the computer wage premium is highest in

12 We used a module available at http://www.oecd.org/skills/piaac/

LMEs and lowest in Nordic CME countries.[13] In LMEs, employees who use computers at work earn 26.5% higher pay than employees who do not, holding other suspects constant. In Continental CMEs, employees who use computers at work earn 21.5% higher pay than employees who do not (the coefficient for using computers plus the coefficient for using computers in Continental CMEs), and in Nordic CMEs the figure is 10.3% (Model 1). The same order—the highest effect on earnings in LMEs (16.8%) and the lowest in Nordic CMEs (1.2%)—is found when we add controls for occupation and industry (Model 2). These results indicate that the wage gaps between workers who do and do not use computers at work are the widest in LMEs and the narrowest in Nordic CMEs.[14]

Analytically, we prefer to estimate the computer wage premium without detailed information on occupation because computer skills may enable workers to qualify for jobs in higher paying occupations. Also, countries' industry composition may be partly an outcome of their institutional setting, including the education and training system, the financial system and corporate governance. That means that the results shown in Models 3–5 may underestimate the significance of the institutional setting for the computer wage gap level. Still, if one-digit occupation dummies and one-digit industry dummies are included instead of the four occupation dummies and manufacturing sector, the results are similar (Model 3)—except for Continental CMEs, where the computer wage premium is no different from that in LMEs. The computer-use wage differential is 13.9% in LMEs and 1.6% in Nordic CMEs. Moreover, if 48 two-digit occupation dummies (data are unavailable for Finland) and 21 two-digit industry dummies are included, the computer-use wage differential is still much higher in LMEs than in Nordic CMEs. It is the same when measures for workers' cognitive and computer-specific skills are included. An explanation for the highest computer wage premium in LMEs, taking into account the skill structure across countries, could be the greater legitimation of workers' claims for wage increases in LMEs.

Could the results shown in Table 1 be simply an outcome of higher levels of wage inequality in LMEs as compared with CMEs? The results presented in Table 2 for the estimated effects of computer use at work on a standardized wage demonstrate that even when the wage structure is controlled for, the computer wage premium is highest in LMEs and lowest in Nordic CMEs. These results hold when we add controls for occupation and industry (Models 2–4), but not controls for workers' cognitive and computer-specific skills (Model 5). Our findings that computer use at work is considerably more highly rewarded in LMEs and less highly rewarded in Nordic CMEs, even when wage structure is controlled for, soundly support the argument for an interaction between technology and politics in the wage determination process. That CMEs moderate the effect of computers on wages may be because in competitive markets skilled workers obtain higher returns. This may be due to their higher productivity and the limited supply of such workers. Also, the claims of the

13 These results hold for both complex and simple uses of a computer at work. In additional analyses (not shown), we used the detailed information on computer use at work to differentiate workers who use computers at work for complex tasks from those who use them for simple tasks.

14 But the results do not indicate that computer-based workers in LMEs earn more, on average, than computer-based workers in other countries. In fact, the highest (average) hourly wage among computer workers as well as non-computer workers was found to be in Nordic LMEs. That is, the higher computer wage premium in LME countries is partly (but not entirely: see Table 2) due to the average wages of non-computer workers in Nordic CMEs ($18.3) being higher than those of non-computer workers in LMEs ($13.7). This reduces the within-country premium in relative terms.

higher qualified workers who use a computer at work should win more legitimacy and power in LMEs than in countries with more regulated markets.

As expected, the results shown in Tables 1 and 2 reveal a significant gap between LMEs and Nordic CMEs in the rewards for using a computer at work, the former illustrating the highest rewards. We expected to find that Continental CME countries lie in between these two varieties of capitalism, but the results here are less robust. This is partly due to greater variance among countries assigned to this category in their wage-setting and vocational education systems (Table 3). To better understand the computer wage premium in Continental CME countries, we estimated the same models in Tables 1 and 2 with two additional distinctions in Coordinated CME countries (data not shown): (a) a group comprising Japan and Korea, where coordination takes place across groups of companies rather than in the industrial sector, and collective bargaining coverage is much lower; (b) a group comprising France, Italy and Spain, which may constitute a Mediterranean cluster associated with high levels of state intervention (Hall and Soskice, 2001). As we would expect, the computer wage premium in group-coordinated economies (i.e. Japan and Korea) is higher than in industry-coordinated economies (i.e. Austria, Belgium, France, Germany, Italy, the Netherlands and Spain) where collective bargaining coverage is much higher. Also, the computer wage premium in a Mediterranean cluster (i.e., France, Italy and Spain) characterized by high levels of state intervention is lower than in other Coordinated CME countries. We further assess the sensitivity of the results to our classifying countries into nominal groups by estimating models by country. Overall, the results (shown in Table 3) reveal a pattern similar to the findings by the three varieties of capitalism.

## 5.2 The role of pay-setting institutions and education and training system in cross-national variability in returns on computer use

Table 4 presents results from a random intercept and a random slope hierarchical model to predict logged hourly wages (full results are presented in Appendix C). At the country level, we estimated the effect of indicators for pay-setting institutions on average wages, and more importantly on the computer wage premium. A negative sign for the interaction between computer use and countries' continuous indicators (bargaining coverage, public education spending and public investment in vocational training) indicates that the computer wage premium tends to decrease with an increase in the respective indicator. Since data on nominal measures for hourly wages are available for only 16 countries, we estimated separate models for each indicator, and in Model 6, we included several indicators in one model.

Consistent with our first hypothesis, that widespread bargaining coverage can stimulate practices and norms of equity across workplaces and thereby mute upward pressure of high-wage workers who use a computer at work for pay raise (H1), we find that the computer wage premium tends to decrease with an increase in bargaining coverage (Model 1 in Table 4). To test the second part of our first hypothesis—that the computer wage premium will be highest in countries where collective bargaining is decentralized to the company level—we estimated a hierarchical model in which bargaining level (Model 2) and bargaining centralization (Model 3) explain the variance among countries in the computer wage

**Table 4.** Effects of individual- and country-level variables on earnings, 2011–2015

| Dependent variable | Ln hourly wage | | | | | |
|---|---|---|---|---|---|---|
| | Model 1 | Model 2 | Model 3 | Model 4 | Model 5 | Model 6 |
| Country-level effect: on the intercept | | | | | | |
| Bargaining coverage rate | 0.003** | – | – | – | – | 0.003** |
| | (0.001) | | | | | (0.002) |
| Level of wage bargaining—intermediate between sector and company bargaining† | – | −0.059 | – | – | – | – |
| | | (0.181) | | | | |
| Level of wage bargaining—sector or industry level† | – | −0.142 | – | – | – | – |
| | | (0.099) | | | | |
| Level of wage bargaining—intermediate between central and industry bargaining† | – | 0.159** | – | – | – | – |
| | | (0.058) | | | | |
| Level of wage bargaining—central level† | – | 0.239*** | – | – | – | – |
| | | (0.056) | | | | |
| Bargaining centralization | – | – | 0.836** | – | – | – |
| | | | (0.264) | | | |
| Public education spending | – | – | – | 0.151*** | | 0.173*** |
| | | | | (0.031) | | (0.039) |
| Public investment in vocational training | – | – | – | – | 0.003*** | −0.003 |
| | | | | | (0.001) | (0.002) |
| Country-level effect: on the computer wage premium | | | | | | |
| Bargaining coverage rate | −0.001*** | – | – | – | – | −0.001*** |
| | (0.000) | | | | | (0.000) |
| Level of wage bargaining—intermediate between sector and company bargaining† | – | −0.077*** | – | – | – | – |
| | | (0.021) | | | | |
| Level of wage bargaining—sector or industry level† | – | −0.067 | – | – | – | – |
| | | (0.035) | | | | |
| Level of wage bargaining—intermediate between central and industry bargaining† | – | −0.094*** | – | – | – | – |
| | | (0.013) | | | | |
| Level of wage bargaining—central level† | – | −0.103*** | – | – | – | – |
| | | (0.014) | | | | |
| Bargaining centralization | – | – | −0.090 | – | – | – |
| | | | (0.155) | | | |
| Public education spending | – | – | – | −0.049*** | – | −0.046*** |
| | | | | (0.012) | | (0.014) |
| Public investment in vocational training | – | – | – | – | −0.001*** | 0.000 |
| | | | | | (0.000) | (0.000) |
| 9 one-digit occupation dummies | Yes | Yes | Yes | Yes | Yes | Yes |

*continued*

**Table 4.** *Continued*

| Dependent variable | Ln hourly wage | | | | | |
|---|---|---|---|---|---|---|
| | Model 1 | Model 2 | Model 3 | Model 4 | Model 5 | Model 6 |
| 9 one-digit industry dummies | Yes | Yes | Yes | Yes | Yes | Yes |
| *N* (Individual) | 48 738 | 48 738 | 43 471 | 48 738 | 48 738 | 48 738 |
| *N* (country) | 16 | 16 | 14 | 16 | 16 | 16 |

*Source:* Authors' calculations of the PIAAC.

*Notes*: The analysis covers wage and salary workers aged 20–65 years. Sample weights are applied. The coefficients are followed by standard errors in parentheses. Control variables are omitted in the interest of parsimonious presentation. The controls in Models 1–6 include gender, native born, education, work experience, work experience$^2$, full time, type of contract, tenure, sector, large firm and part of larger organization. Full results are presented in Appendix C.

†Ref: bargaining predominantly takes place at the local or company level.

$^{**}P < 0.01$; $^{***}P < 0.001$.

gap.[15] As expected, decentralization of collective bargaining is found associated with a higher computer wage premium. Although our estimation method reveals the 'average' effect of computer on wages, we expect that in countries with centralized wage bargaining, using a computer at work will also have a more equal effect on the wage structure. This is because unskilled workers tend to do better under economy-wide bargaining, whereas skilled workers may gain more from company bargaining, especially where it allows some individual pay bargaining.

Before turning to the results for the interaction between the education systems and the computer wage premium, in Table 5, we review the extent of international differences in the distribution of computer use at work in the wage sample. Two patterns stood out. First, coordinated CME countries showed the lowest levels of computer use, in particular among low-wage workers. The lowest levels of computer use were in Italy and Spain, characterized by medium levels of public investment in VET, but little firm involvement as compared with 'collective' or 'statist' skill formation systems in other continental European countries (Busemeyer and Iversen, 2012). This finding is consistent with Iversen and Stephens' (2008) thesis that the skill formation system in these countries favors skilled workers and largely ignores the interests of low-skilled and semi-skilled workers. Second, a striking pattern is the lower level of computer-use inequality in Nordic CMEs than elsewhere: a difference of 31.9

15 While centralization and coordination can ideally amount to the same thing, in practice fully decentralized bargaining, at the company level, might be highly coordinated, for instance, if all negotiations were conducted by the same union, or employers took advice from one major association before signing agreements. Conversely, highly centralized bargaining with peak-level confederations can be fairly uncoordinated, when there is poor monitoring and implementation at lower levels. We therefore estimate additional models in which we include at the country level an indicator for *coordination of wage setting*, defined as the degree to which wage bargaining is (strategically) coordinated by unions and employers. In line with H1, we find the highest level of computer wage premium in countries with fragmented wage bargaining, confined largely to individual firms or plants (e.g. the USA), and the lowest level in countries with the highest level of wage coordination—Belgium and Finland, where maximum or minimum wage rates/increases are based on centralized bargaining (data not shown).

**Table 5.** Distribution of computer use at work by country and three national 'varieties' of capitalism, 2011–2015

| | | Percentile | | | Differential | | |
|---|---|---|---|---|---|---|---|
| | Mean | 10 | 50 | 90 | 50–10 | 90–50 | 90–10 |
| LME countries | | | | | | | |
| Australia | 74.6 | 56.5 | 76.0 | 96.5 | 19.5 | 20.5 | 40.0 |
| Canada | 73.1 | 52.7 | 76.3 | 95.3 | 23.6 | 19.0 | 42.6 |
| Ireland | 68.1 | 40.9 | 74.3 | 93.0 | 33.4 | 18.6 | 52.1 |
| Israel | 68.9 | 34.3 | 65.0 | 89.8 | 30.7 | 24.7 | 55.4 |
| New Zealand | 71.5 | 43.2 | 67.6 | 96.8 | 24.4 | 29.2 | 53.6 |
| UK | 75.3 | 49.3 | 72.0 | 99.3 | 22.7 | 27.3 | 50.0 |
| USA | 74.2 | 49.2 | 69.4 | 92.4 | 20.2 | 23.0 | 43.2 |
| Average | 72.2 | 46.6 | 71.5 | 94.7 | 24.9 | 23.2 | 48.1 |
| Continental CME countries | | | | | | | |
| Austria | 70.0 | 43.6 | 66.9 | 94.6 | 23.3 | 27.6 | 50.9 |
| Belgium | 71.3 | 40.0 | 63.1 | 95.1 | 23.2 | 31.9 | 55.1 |
| France | 65.3 | 38.0 | 56.2 | 93.3 | 18.2 | 37.1 | 55.3 |
| Germany | 66.6 | 47.5 | 70.2 | 99.5 | 22.7 | 29.3 | 52.0 |
| Italy | 45.4 | 23.6 | 43.5 | 75.2 | 20.0 | 31.6 | 51.6 |
| Japan | 72.8 | 49.3 | 74.2 | 89.7 | 24.9 | 15.4 | 40.4 |
| Korea | 64.3 | 39.5 | 60.7 | 71.6 | 21.2 | 10.9 | 32.1 |
| The Netherlands | 79.0 | 62.2 | 82.3 | 94.2 | 20.0 | 12.0 | 32.0 |
| Spain | 53.5 | 28.7 | 51.1 | 90.7 | 22.5 | 39.6 | 62.1 |
| Average | 65.4 | 41.4 | 63.1 | 89.3 | 21.8 | 26.2 | 47.9 |
| Nordic CME countries | | | | | | | |
| Denmark | 79.1 | 60.4 | 76.1 | 93.3 | 15.7 | 17.2 | 32.9 |
| Finland | 80.3 | 48.6 | 75.4 | 97.4 | 26.8 | 22.0 | 48.9 |
| Norway | 84.7 | 72.2 | 82.5 | 98.2 | 10.3 | 15.7 | 26.0 |
| Sweden | 82.9 | 67.1 | 83.7 | 95.8 | 16.6 | 12.1 | 28.7 |
| Average | 81.8 | 62.1 | 79.4 | 96.2 | 17.3 | 16.8 | 34.1 |

*Source:* Authors' calculations of the PIAAC.
*Notes*: The analysis covers wage and salary workers aged 20–65 years. Sample weights are applied.

percentage points between workers located in the upper tail (90th percentile) and lower tail (10th percentile), compared with much wider gaps in LMEs (45.4) and in Continental CMEs (48.3). The smaller dispersal of computer use across the wage structure in Nordic CMEs than elsewhere is due to the higher percentage of workers who use a computer at work in both low-wage (62.9%) and median-wage (86.4%) workers. The lower level of computer-use inequality in Nordic CMEs is a result of the institutional system, which fosters high levels of computer skills, especially at the bottom of the skills distribution.

To test our second and last hypothesis—that heavy investment in public education and extensive vocational training should reduce the computer wage premium—we estimate hierarchical models in which we interact indicators for the education system with the computer wage gap. Here too the results are consistent with our expectations. We find that an increase in public spending on education (Models 4 and 6) and an increase in public investment in vocational training (Model 5) decrease the computer wage premium, apparently by increasing the supply of workers who use computers at work.

## 6. Conclusions

This study explores the computer wage premium from a cross-national comparative perspective, utilizing unique data from the Survey of Adult Skills. The results of the analyses and diverse sensitivity tests are consistent with the main argument: institutions mediate the computer wage premium. We found that the institutional setting in LMEs exerted the highest (average) effect of computers on wages. The institutional setting in Nordic CMEs exerted the lowest effect. These results mirror the centrality of coordinated markets, grounded in strong unions, centralized wage bargaining, and publicly funded education and training, for a relatively low computer wage premium, and consequently a more equal wage distribution.

The results also provide some indirect evidence as to the mechanisms that link computer use to labor market inequality in different institutional contexts. Controlling for available measures for workers' skills (assumed to be closely correlated with workers' productivity), we find that using a computer at work has a considerable effect on wages in LMEs and a minor effect on wages in Nordic CMEs. These findings may suggest that the sizeable effect of computers on wage structure, in LMEs above all, is largely explained by their enhancing workers' bargaining power, while productivity-enhancing mechanisms (i.e. returns on computer skills or general cognitive skills) play a secondary part.

Our study is not without limitations. First and foremost, the individual-level data on computer use and wages, linked to macro-level capitalist system typologies and national institutional context as explanatory factors, do not enable examination of the direct effect of wage determination norms and practices on the computer wage premium, but only examination of the possible trace of these processes. Second, although the PIAAC offers rich information on computer use at work, computer-based technologies' effects on the wage structure reach far beyond the individual who uses (or does not use) a computer at work. Computer-based technologies are known to have far-reaching implications for the context in which workers and employers operate by changing the occupational composition of the workplace (Acemoglu and Autor, 2011), work practices (Bresnahan *et al.*, 2002), social relations at the workplace (Vallas, 1993) and union strength (Kristal, 2019). Lastly, our study compares the wages of workers who use a computer at work with those of workers who do not, without identifying the specific computer-based technologies. Having data on different types of technologies might show that our results also reflect the type of knowledge and innovation at work in the three national 'varieties' of capitalism, which are closely linked to the education and training system and wage-setting institutions.[16] This indicates that the institutional linkages that give rise to specific configurations of capitalism may not be fully observed when the focus is on a specific institutional domain or on several domains.

Despite these limitations, this study makes further contributions to research on comparative political economy and income inequality, and in considering what should be done to moderate inequality. First, our finding that the three varieties of capitalism differ with

16 By type of innovation process, studies usually mean Hall and Soskice's (2001, pp. 38–40) distinction between technologies characterized by radical innovation that can be found in biotechnology or telecommunications, and technologies such as mechanical engineering, which would feature more incremental innovations. That the institutional framework of LMEs is supportive of radical innovation, but tend to limit firms' capacities for incremental innovation, while the institutional framework of CMEs is better at supporting incremental innovation, finds some to strong support in the comparative literature (see Schneider and Paunescu, 2012).

respect to the computer wage premium shows the marked institutional variance among countries in the age of global neoliberalism. Second, our study sets out a new research agenda that highlights the interactions between technology and politics in the wage determination process, aiming to solve the puzzle of the divergent inequality trends among countries in the computer-revolution age. The new agenda developed in this article demonstrates that politics, broadly defined, can locally mitigate the effects of global technological change on wages by stimulating norms of fair pay and equity. This article focuses on the computer wage premium, but it is possible to theorize additional ways whereby technology interacts with institutions in generating wage inequality. In fact, the literature on technology adoption across countries, in particular studies on innovations induced by labor costs (see Acemoglu, 2010, for a summary of this literature), indicates that labor market regulations significantly influence technology adoption, hence wage inequality. Recently Alesina *et al.* (2018) showed that more labor regulation biases technology toward low-skill sectors, while less labor regulation biases technology toward high-skill sectors,[17] a finding that can partly explain inequality difference between CME and LME countries. That politics can locally mitigate the effects of global technological adoption and usages on wages, signifies the importance of studying the interactions between technology and politics for a better understanding of the divergent inequality trends among countries.

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17 The rationale is that computerization is embedded in new machines that mostly replace workers, therefore a technology is adopted only if wages are sufficiently high.

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## Appendix A: Descriptive statistics of variables used in the analysis

| | *N* | Demography | | Education (ref: primary) | | Employment | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Male | Native born | Secondary | High | Full time | Work experience | Manuf. | Large workplace | Part of larger organization | Public sector |
| LME countries | | | | | | | | | | | |
| Australia | 3647 | 0.53 | 0.68 | 0.37 | 0.43 | 0.79 | 19.42 | 0.14 | 0.20 | 0.68 | 0.22 |
| Canada | 14 867 | 0.51 | 0.75 | 0.37 | 0.54 | 0.85 | 20.38 | 0.16 | 0.24 | 0.68 | 0.28 |
| Ireland | 2716 | 0.47 | 0.80 | 0.38 | 0.46 | 0.72 | 17.06 | 0.14 | 0.19 | 0.68 | 0.29 |
| Israel | 2291 | 0.48 | 0.75 | 0.39 | 0.54 | 0.84 | 18.08 | 0.14 | 0.21 | 0.60 | 0.32 |
| New Zealand | 3209 | 0.51 | 0.71 | 0.32 | 0.51 | 0.80 | 20.45 | 0.14 | 0.17 | 0.64 | 0.26 |
| UK | 4542 | 0.52 | 0.87 | 0.39 | 0.44 | 0.77 | 20.07 | 0.14 | 0.30 | 0.70 | 0.29 |
| USA | 2675 | 0.50 | 0.86 | 0.49 | 0.44 | 0.87 | 20.42 | 0.14 | 0.27 | 0.65 | 0.22 |
| Continental CME countries | | | | | | | | | | | |
| Austria | 2740 | 0.51 | 0.84 | 0.67 | 0.19 | 0.81 | 19.23 | 0.19 | 0.22 | 0.64 | 0.24 |
| Belgium | 2633 | 0.52 | 0.94 | 0.45 | 0.43 | 0.82 | 19.99 | 0.21 | 0.24 | 0.63 | 0.31 |
| Germany | 3143 | 0.52 | 0.87 | 0.58 | 0.34 | 0.77 | 20.05 | 0.26 | 0.26 | 0.62 | 0.22 |
| France | 3479 | 0.51 | 0.90 | 0.47 | 0.36 | 0.86 | 18.88 | 0.17 | 0.21 | 0.62 | 0.25 |
| Italy | 1781 | 0.57 | 0.90 | 0.40 | 0.16 | 0.82 | 17.53 | 0.28 | 0.16 | 0.47 | 0.22 |
| Japan | 3112 | 0.56 | 1.00 | 0.43 | 0.48 | 0.83 | 18.94 | 0.24 | 0.19 | 0.68 | 0.12 |
| Korea | 3005 | 0.58 | 0.99 | 0.41 | 0.46 | 0.88 | 13.08 | 0.25 | 0.19 | 0.48 | 0.16 |
| The Netherlands | 2930 | 0.52 | 0.90 | 0.41 | 0.37 | 0.67 | 19.37 | 0.15 | 0.23 | 0.69 | 0.29 |
| Spain | 2392 | 0.53 | 0.88 | 0.24 | 0.41 | 0.86 | 17.40 | 0.13 | 0.14 | 0.60 | 0.25 |
| Nordic CME countries | | | | | | | | | | | |
| Denmark | 4206 | 0.51 | 0.91 | 0.40 | 0.44 | 0.86 | 22.29 | 0.17 | 0.19 | 0.69 | 0.37 |
| Finland | 3131 | 0.48 | 0.96 | 0.43 | 0.48 | 0.90 | 19.20 | 0.18 | 0.15 | 0.74 | 0.36 |
| Norway | 2923 | 0.50 | 0.88 | 0.40 | 0.43 | 0.82 | 19.45 | 0.10 | 0.22 | 0.54 | 0.37 |
| Sweden | 2763 | 0.50 | 0.86 | 0.51 | 0.35 | 0.89 | 20.23 | 0.15 | 0.21 | 0.79 | 0.38 |

*continued*

*Continued*

| | Occupations (ref: elementary) | | | | Skill | |
|---|---|---|---|---|---|---|
| | Skilled | Semi-skilled white collar | Semi-skilled blue collar | Managing other employees | Mean computer-specific skill scores | Mean numeracy skill scores |
| LME countries | | | | | | |
| Australia | 0.48 | 0.26 | 0.17 | 0.42 | 291 | 275 |
| Canada | 0.55 | 0.23 | 0.16 | 0.31 | 284 | 271 |
| Ireland | 0.41 | 0.35 | 0.14 | 0.32 | 281 | 265 |
| Israel | 0.58 | 0.25 | 0.13 | 0.32 | 277 | 262 |
| New Zealand | 0.53 | 0.25 | 0.17 | 0.44 | 290 | 277 |
| UK | 0.42 | 0.35 | 0.14 | 0.37 | 286 | 273 |
| USA | 0.49 | 0.29 | 0.16 | 0.34 | 281 | 261 |
| Continental CME countries | | | | | | |
| Austria | 0.43 | 0.29 | 0.20 | 0.36 | 285 | 280 |
| Belgium | 0.48 | 0.25 | 0.18 | 0.30 | 283 | 287 |
| Germany | 0.38 | 0.31 | 0.23 | 0.29 | 284 | 278 |
| France | 0.46 | 0.25 | 0.19 | 0.32 | – | 263 |
| Italy | 0.30 | 0.28 | 0.30 | 0.22 | – | 255 |
| Japan | 0.36 | 0.38 | 0.20 | 0.30 | 298 | 293 |
| Korea | 0.30 | 0.38 | 0.20 | 0.33 | 284 | 268 |
| The Netherlands | 0.53 | 0.30 | 0.11 | 0.34 | 292 | 288 |
| Spain | 0.34 | 0.35 | 0.18 | 0.27 | – | 258 |
| Nordic CME countries | | | | | | |
| Denmark | 0.51 | 0.24 | 0.17 | 0.21 | 287 | 287 |
| Finland | 0.46 | 0.27 | 0.21 | 0.24 | 293 | 292 |
| Norway | 0.51 | 0.30 | 0.14 | 0.35 | 290 | 287 |
| Sweden | 0.49 | 0.28 | 0.19 | 0.34 | 291 | 289 |

*Source*: Authors' calculations of the PIAAC.
*Note*: The analysis covers wage and salary workers aged 20–65 years.

## Appendix B: OLS regression estimates of the effect of computer use on nominal and standardized wage in LMEs, Continental CMEs and Nordic CMEs

| Dependent variable | Ln hourly wage | | | | | Hourly wage deciles | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Model 1 | Model 2 | Model 3 | Model 4 | Model 5 | Model 1 | Model 2 | Model 3 | Model 4 | Model 5 |
| Computer use at work | 0.265 | 0.168 | 0.139 | 0.138 | 0.109 | 1.312 | 0.826 | 0.772 | 0.755 | 0.534 |
| | (0.012) | (0.012) | (0.012) | (0.012) | (0.015) | (0.081) | (0.080) | (0.080) | (0.090) | (0.089) |
| Continental CMEs × Computer | −0.050 | −0.026 | −0.005 | 0.000 | 0.018 | −0.176 | −0.095 | −0.064 | −0.045 | 0.157 |
| | (0.014) | (0.014) | (0.014) | (0.014) | (0.019) | (0.100) | (0.097) | (0.094) | (0.098) | (0.098) |
| Nordic CMEs × Computer | −0.162 | −0.156 | −0.123 | −0.142 | −0.136 | −0.344 | −0.384 | −0.243 | −0.381 | −0.176 |
| | (0.014) | (0.013) | (0.013) | (0.016) | (0.017) | (0.103) | (0.099) | (0.093) | (0.100) | (0.099) |
| Male | 0.228 | 0.186 | 0.192 | 0.184 | 0.171 | 1.009 | 0.842 | 0.831 | 0.729 | 0.674 |
| | (0.006) | (0.007) | (0.007) | (0.008) | (0.009) | (0.044) | (0.046) | (0.049) | (0.058) | (0.063) |
| Native born | −0.023 | −0.029 | −0.029 | −0.025 | −0.056 | 0.201 | 0.156 | 0.147 | 0.119 | −0.060 |
| | (0.009) | (0.008) | (0.007) | (0.007) | (0.012) | (0.073) | (0.072) | (0.070) | (0.076) | (0.073) |
| Medium education | 0.068 | 0.047 | 0.050 | 0.052 | 0.035 | 0.452 | 0.328 | 0.330 | 0.322 | 0.249 |
| | (0.010) | (0.010) | (0.010) | (0.010) | (0.015) | (0.052) | (0.053) | (0.051) | (0.053) | (0.075) |
| High education | 0.311 | 0.198 | 0.164 | 0.163 | 0.129 | 1.973 | 1.306 | 1.128 | 1.115 | 0.928 |
| | (0.012) | (0.012) | (0.012) | (0.012) | (0.017) | (0.059) | (0.058) | (0.056) | (0.058) | (0.087) |
| Work experience | 0.024 | 0.021 | 0.021 | 0.020 | 0.024 | 0.139 | 0.124 | 0.121 | 0.118 | 0.128 |
| | (0.001) | (0.001) | (0.001) | (0.001) | (0.001) | (0.007) | (0.007) | (0.007) | (0.007) | (0.008) |
| Work experience squared | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | −0.002 | −0.002 | −0.002 | −0.002 | −0.002 |
| | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) |
| Full time | −0.137 | −0.171 | −0.165 | −0.173 | −0.140 | 0.122 | −0.102 | −0.108 | −0.184 | 0.126 |
| | (0.011) | (0.011) | (0.011) | (0.011) | (0.015) | (0.066) | (0.069) | (0.069) | (0.073) | (0.087) |
| Permanent contract† | 0.134 | 0.121 | 0.126 | 0.126 | 0.128 | 0.336 | 0.292 | 0.302 | 0.298 | 0.170 |
| | (0.008) | (0.007) | (0.007) | (0.007) | (0.009) | (0.042) | (0.040) | (0.038) | (0.038) | (0.051) |
| Tenure | 0.009 | 0.008 | 0.008 | 0.008 | 0.008 | 0.053 | 0.047 | 0.048 | 0.048 | 0.050 |

*continued*

*Continued*

| Dependent variable | Ln hourly wage | | | | | Hourly wage deciles | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Model 1 | Model 2 | Model 3 | Model 4 | Model 5 | Model 1 | Model 2 | Model 3 | Model 4 | Model 5 |
| | (0.000) | (0.000) | (0.000) | (0.000) | (0.001) | (0.002) | (0.002) | (0.002) | (0.002) | (0.002) |
| Large firm | 0.191 | 0.166 | 0.153 | 0.147 | 0.157 | 0.935 | 0.824 | 0.751 | 0.647 | 0.715 |
| | (0.008) | (0.008) | (0.008) | (0.008) | (0.009) | (0.051) | (0.050) | (0.052) | (0.052) | (0.053) |
| Public sector | 0.066 | 0.063 | 0.066 | 0.057 | 0.057 | 0.145 | 0.127 | 0.186 | 0.088 | 0.154 |
| | (0.007) | (0.007) | (0.009) | (0.009) | (0.011) | (0.044) | (0.042) | (0.051) | (0.060) | (0.057) |
| Part of larger organization | 0.051 | 0.059 | 0.058 | 0.064 | 0.057 | 0.078 | 0.159 | 0.196 | 0.216 | 0.139 |
| | (0.007) | (0.007) | (0.007) | (0.007) | (0.009) | (0.038) | (0.036) | (0.037) | (0.040) | (0.043) |
| Manufacturing | – | 0.061 | – | – | – | – | 0.282 | – | – | – |
| | | (0.009) | | | | | (0.041) | | | |
| Skilled occupations‡ | – | 0.288 | – | – | – | – | 1.809 | – | – | – |
| | | (0.015) | | | | | (0.096) | | | |
| Semi-skilled white collar‡ | – | 0.020 | – | – | – | – | 0.251 | – | – | – |
| | | (0.014) | | | | | (0.091) | | | |
| Semi-skilled blue collar‡ | – | 0.074 | – | – | – | – | 0.649 | – | – | – |
| | | (0.014) | | | | | (0.082) | | | |
| Managing other employees | – | 0.117 | – | – | – | – | 0.480 | – | – | – |
| | | (0.006) | | | | | (0.043) | | | |
| General cognitive skills | – | – | – | – | 0.001 | – | – | – | – | 0.006 |
| | | | | | (0.000) | | | | | |
| | | | | | | | | | | (0.001) |
| Computer-specific skills | – | – | – | – | 0.000 | – | – | – | – | 0.002 |
| | | | | | (0.000) | | | | | (0.001) |
| Continental CMEs | −0.033 | −0.038 | −0.050 | −0.049 | −0.049 | 0.231 | 0.252 | 0.232 | 0.191 | −0.094 |
| | (0.012) | (0.012) | (0.011) | (0.011) | (0.017) | (0.087) | (0.078) | (0.077) | (0.086) | (0.087) |

*continued*

*Continued*

| Dependent variable | Ln hourly wage | | | | | Hourly wage deciles | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Model 1 | Model 2 | Model 3 | Model 4 | Model 5 | Model 1 | Model 2 | Model 3 | Model 4 | Model 5 |
| Nordic CMEs | 0.373 | 0.379 | 0.346 | 0.437 | 0.345 | 0.193 | 0.247 | 0.094 | 0.196 | −0.080 |
| | (0.013) | (0.013) | (0.012) | (0.014) | (0.016) | (0.096) | (0.088) | (0.082) | (0.093) | (0.090) |
| 9 one-digit occupation dummies | No | No | Yes | No | Yes | No | No | Yes | No | Yes |
| 9 one-digit industry dummies | No | No | Yes | No | Yes | No | No | Yes | No | Yes |
| 48 two-digit occupation dummies | No | No | No | Yes | No | No | No | No | Yes | No |
| 21 two-digit industry dummies | No | No | No | Yes | No | No | No | No | Yes | No |
| Constant | 1.929 | 1.971 | 2.549 | 2.095 | 2.236 | 0.316 | 0.347 | 3.276 | 1.103 | 1.607 |
| $R^2$ | 0.364 | 0.415 | 0.433 | 0.444 | 0.450 | 0.381 | 0.442 | 0.460 | 0.477 | 0.481 |
| *N* | 49 140 | 49 140 | 48 738 | 45 607 | 34 835 | 72 185 | 72 185 | 71 401 | 51 033 | 54 152 |

*Source*: Authors' calculations of the PIAAC.

*Notes*: The analysis covers wage and salary workers aged 20–65 years. Sample weights are applied. The coefficients are followed by robust standard errors in parentheses.

LMEs are Australia, Canada (only deciles), Ireland, Israel, New Zealand, the UK and the USA (only deciles). Continental CMEs are Austria (only deciles), Belgium, France, Germany, Italy, Japan, Korea, the Netherlands and Spain. Nordic CMEs are Denmark, Finland, Norway and Sweden (only deciles).

†For Canada and the USA, the type of contract is imputed at the LME level.

‡Ref: elementary occupations.

## Appendix C: Effects of individual and country-level variables on earnings

| Dependent variable | Ln Hourly Wage | | | | | |
|---|---|---|---|---|---|---|
| | Model 1 | Model 2 | Model 3 | Model 4 | Model 5 | Model 6 |
| Individual-level effects | | | | | | |
| Intercept | 2.313*** | 2.423*** | 2.180*** | 1.803*** | 2.334*** | 1.674*** |
| | (0.084) | (0.051) | (0.106) | (0.151) | (0.060) | (0.165) |
| Computer use at work | 0.195*** | 0.174*** | 0.155** | 0.349*** | 0.192*** | 0.372*** |
| | (0.021) | (0.017) | (0.059) | (0.062) | (0.016) | (0.059) |
| Male | 0.153*** | 0.153*** | 0.140*** | 0.153*** | 0.153*** | 0.153*** |
| | (0.019) | (0.019) | (0.017) | (0.019) | (0.019) | (0.019) |
| Native born | 0.038*** | 0.038*** | 0.036*** | 0.038*** | 0.038*** | 0.038*** |
| | (0.009) | (0.010) | (0.011) | (0.010) | (0.010) | (0.009) |
| Medium education | 0.062*** | 0.061*** | 0.064*** | 0.061*** | 0.061*** | 0.061*** |
| | (0.008) | (0.008) | (0.009) | (0.008) | (0.008) | (0.008) |
| High education | 0.203*** | 0.203*** | 0.197*** | 0.203*** | 0.203*** | 0.203*** |
| | (0.016) | (0.016) | (0.017) | (0.016) | (0.016) | (0.016) |
| Work experience | 0.022*** | 0.022*** | 0.022*** | 0.022*** | 0.022*** | 0.022*** |
| | (0.001) | (0.001) | (0.001) | (0.001) | (0.001) | (0.001) |
| Work experience squared | 0.000*** | 0.000*** | 0.000*** | 0.000*** | 0.000*** | 0.000*** |
| | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) |
| Full time | −0.132** | −0.132** | −0.079** | −0.132** | −0.132** | −0.132** |
| | (0.048) | (0.048) | (0.016) | (0.048) | (0.048) | (0.048) |
| Permanent contract | 0.105*** | 0.105*** | 0.099*** | 0.105*** | 0.105*** | 0.105*** |
| | (0.014) | (0.014) | (0.015) | (0.014) | (0.014) | (0.014) |
| Tenure | 0.006*** | 0.006*** | 0.005*** | 0.006*** | 0.006*** | 0.006*** |
| | (0.001) | (0.001) | (0.001) | (0.001) | (0.001) | (0.001) |
| Large firm | 0.124*** | 0.124*** | 0.120*** | 0.124*** | 0.124*** | 0.124*** |
| | (0.010) | (0.010) | (0.010) | (0.010) | (0.010) | (0.010) |
| Public sector | 0.018 | 0.018 | 0.019 | 0.017 | 0.017 | 0.017 |
| | (0.015) | (0.015) | (0.016) | (0.015) | (0.015) | (0.015) |
| Part of larger organization | 0.048*** | 0.048*** | 0.050*** | 0.048*** | 0.048*** | 0.048*** |
| | (0.010) | (0.010) | (0.011) | (0.010) | (0.010) | (0.010) |
| Country-level effect: on the intercept | | | | | | |
| Bargaining coverage rate | 0.003** | – | – | – | – | 0.003** |
| | (0.001) | | | | | (0.002) |
| Level—intermediate between sector and company bargaining† | – | −0.059 | – | – | – | – |
| | | (0.181) | | | | |
| Level—sector or industry† | – | −0.142 | – | – | – | – |
| | | (0.099) | | | | |
| Level—intermediate between central and industry bargaining† | – | 0.159** | – | – | – | – |
| | | (0.058) | | | | |
| Level—central† | – | 0.239*** | – | – | – | – |
| | | (0.056) | | | | |

*continued*

*Continued*

| Dependent variable | Ln Hourly Wage | | | | | |
|---|---|---|---|---|---|---|
| | Model 1 | Model 2 | Model 3 | Model 4 | Model 5 | Model 6 |
| Bargaining centralization | – | – | 0.836** (0.264) | – | – | – |
| Public education spending | – | – | – | 0.151*** (0.031) | | 0.173*** (0.039) |
| Vocational training intensity | – | – | – | – | 0.003*** (0.001) | −0.003 (0.002) |
| Country-level effect: on the computer wage gap | | | | | | |
| Bargaining coverage rate | −0.001*** (0.000) | – | – | – | – | −0.001*** (0.000) |
| Level—intermediate between sector and company bargaining a | – | −0.077*** (0.021) | – | – | – | – |
| Level—sector or industry a | – | −0.067 (0.035) | – | – | – | – |
| Level—intermediate between central and industry bargaining a | – | −0.094*** (0.013) | – | – | – | – |
| Level—central a | – | −0.103*** (0.014) | – | – | – | – |
| Bargaining centralization | – | – | −0.090 (0.155) | – | – | – |
| Public education spending | – | – | – | −0.049*** (0.012) | – | −0.046*** (0.014) |
| Vocational training intensity | – | – | – | – | −0.001*** (0.000) | 0.000 (0.000) |
| 9 one-digit occupation dummies | Yes | Yes | Yes | Yes | Yes | Yes |
| 9 one-digit industry dummies | Yes | Yes | Yes | Yes | Yes | Yes |
| *N* (Individual) | 48 738 | 48 738 | 43 471 | 48 738 | 48 738 | 48 738 |
| *N* (country) | 16 | 16 | 14 | 16 | 16 | 16 |

*Source*: Authors' calculations of the PIAAC.
*Notes*: The analysis covers wage and salary workers aged 20–65 years. Sample weights are applied. The coefficients are followed by standard errors in parentheses.
†Ref: bargaining predominantly takes place at the local or company level.
$^{**}P < 0.01$; $^{***}P < 0.001$.