Basic income as a policy option: Can it add up?

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www.oecd.org/employment/future-of-work.htm

Recent debates of basic income (BI) proposals shine a useful spotlight on the challenges that traditional forms of income support are increasingly facing, and highlight gaps in social provisions that largely depend on income or employment status. A universal "no questions asked" public transfer would be simple and have the advantage that no-one would be left without support. But an unconditional payment to everyone at meaningful but fiscally realistic levels would require tax rises as well as reductions in existing benefits, and would often not be an effective tool for reducing income poverty. Some disadvantaged groups would lose out when existing benefits are replaced by a BI, illustrating the downsides of social protection without any form of targeting at all. Realistically, and in view of the immediate fiscal and distributional consequences of a fully comprehensive BI, reforms towards more universal income support would need to be introduced in stages, requiring a parallel debate on how to finance a more equal sharing of the benefits of economic growth.

An old idea attracting renewed attention

The concept of a basic income (BI), an unconditional transfer paid to everyone, is not new. In several countries, some groups already receive unconditional public transfers. The most important universal payments are child or family benefits (in many European countries, see OECD Family Database) and basic old-age pensions (in about half of OECD countries, see OECD Pensions at a Glance).

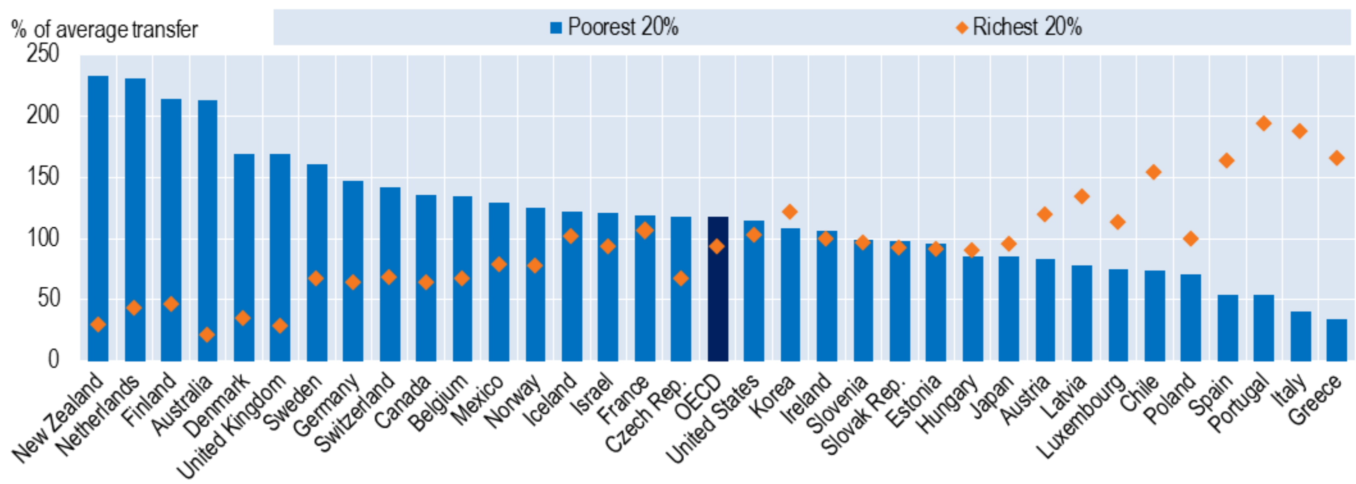
Examples of earlier high-profile campaigns for more comprehensive forms of a BI include those in Canada and the United States. But to date, no country has put a BI in place as a principal pillar of income support for the working-age population. The recent upsurge in attention to BI proposals in OECD countries, including in those with long-standing traditions of providing comprehensive social protection, is therefore remarkable (**Box 1**).

A growing interest in simple, reliable and accessible income support can be linked to major economic trends and to social concerns associated with them, including growing inequality, the rise in atypical forms of employment, also associated with the digital transformation, the risk of job losses due to automation, as well as imbalances between work, family and leisure. In particular, existing social protection systems were, in large part, modelled on employer-employee contracts, stable career patterns, and social compacts, which can appear outdated today, creating challenges for maintaining effective support for all those in need. Even now, when a large majority of workers are still in traditional forms of employment, in around half of OECD countries, fewer than 50% of active jobseekers receive unemployment support (Society at a Glance: OECD Social Indicators 2016). Lower tier safety nets, such as minimum-income benefits for the poor, are typically less accessible still, also because of the negative stigma that can come with claiming these transfers.

Incomplete coverage is one reason why low-income groups in some countries are less likely to benefit from cash support than better-off families (**Figure 1**). In addition, not all social transfers are designed to redistribute from rich to poor.

Figure 1. Existing cash support can be patchy and is not always tightly targeted to the poor

Transfers received by working-age individuals in low and high-income groups, 2013 or latest year available



Note: Age group 18-65, 18-62 in France. Public social cash transfers at the household level, adjusted for household size. Income groups refer to disposable incomes. Additional data provided by France show that, without counting old-age and disability pensions, the bottom 20% in France receive about three times as much as the top 20%.

Source: Calculations based on the OECD Income Distribution Database.

Box 1. Basic income debates in OECD countries

Although the idea of a BI has been discussed by philosophers for centuries, there are few cases of BIs actually being introduced in the OECD area. Perhaps the closest example is the Alaska Permanent Fund, which distributes part of that state's oil revenues to all its residents on a per-capita basis. Previous experiments that are frequently cited as being BIs such as the US negative income tax experiments of the late 1960s and early 1970s and the Canadian MINCOME programme are in fact closer to means-tested benefits than a flat-rate payment to the whole population. Nevertheless, the idea has recently attracted greater interest in a number of OECD countries. In Switzerland, a proposal to change the constitution to give everyone the right to a basic income at a level that would enable recipients "to live a dignified life and to participate in public life" was rejected in a 2016 referendum by a margin of 77% to 23%. Although the referendum question itself did not specify a level for the BI, those campaigning in favour of it proposed a level of CHF 30 000 per year. This is equivalent to more than half of median income for a single person in Switzerland, a much higher level than has been proposed elsewhere.

Some countries have started or are planning pilots to evaluate the impact of specific BI programmes. The most developed of these experiments is in Finland, where 2 000 current recipients of unemployment assistance benefits have been paid a BI of EUR 560 per month since January 2017, equivalent to just over a quarter of median household income for a single person. The amount, and the fact that some other benefits, including housing benefits, are kept in place, is similar to the scenario for Finland analysed in this note. However, in contrast to the scenarios assessed here, taxes for those receiving the BI are unchanged in the Finnish experiment, and those receiving higher levels of unemployment benefits are not losing out. The scheme would not therefore be budget-neutral if it were applied nationally. The Finnish pilot study will be particularly informative for understanding the impact a BI may have on recipients' employment behaviour and other time use.

Different types of experiment have been announced in the Netherlands. The ministry of Social Affairs and Employment will give up to 25 municipalities the possibility to make experimental changes to social assistance (*Participatiewet*) from 2017 onwards, in order to examine the effectiveness of different policy options to stimulate participation in the labour market. The experiments do not correspond to a universal BI as discussed in the note, however. A limited number of existing claimants will receive different types of "treatment" (intensive support for integration into work, no job search requirements or a broader exemption of labour income from applicable means tests). The central goal is to examine the effectiveness of different policy options to stimulate participation in the labour market and overcoming benefit dependence.

In Canada, the Ontario Government has committed to testing a basic income as an approach to more effectively lifting people out of poverty and improving health, housing and employment outcomes in the province. Ontario is currently holding consultations to seek public input to help inform the design of the pilot and will move forward with implementing it in 2017. The Government of Québec tasked an expert panel to look into new approaches that could be used to fight poverty more effectively, promote social inclusion and move towards introducing a guaranteed minimum income.

BI proposals are also in the public debate or under policy consideration in many other countries. In France, a Senate Committee recently recommended an experiment and several presidential candidates proposed different variants of a BI. The most high profile of these plans would have replaced existing social assistance and in-work benefits with a basic income set at a level slightly higher than the social assistance amount for a single person. But those receiving the BI would also have had to pay a means-tested "contribution" towards it, which would be equal to the basic income itself for those with higher incomes, who would thus have seen no change in their income. This is very different from the universal BI considered in this note. Some other proposals in France are closer to the scenario examined in this note, with BI amounts close to the level of existing social assistance benefits, and partially financed by abolishing tax-free allowances.

In the United States, the billionaire entrepreneur Elon Musk is proposing to conduct his own BI experiment for a small number of people, and several other innovative local and citizen initiatives have been reported in the media. In many of these cases, there are, however, currently relatively few concrete details as to the parameters of the proposed programmes.

As well as discussions in the political sphere, a large number of recent academic studies have examined the possible impacts of a BI in comparative perspective or various country contexts, suggesting that the idea is likely to remain under active discussion for some time. Examples are Atkinson (2015), Widerquist et al. (2013), as well as studies for the United Kingdom (Reed and Lansley, 2016), Germany (Spermann, 2006; Sommer, 2016) and Hungary (Bistván et al. 2014).[1]

1. Atkinson A.B. (2015), *Inequality: What Can Be Done?*, Harvard University Press; Widerquist, K., J.A. Noguera, Y. Vanderborght and J. de Wispelaere (eds.) (2013), *Basic Income. An Anthology of Contemporary Research*, Wiley Blackwell; H. Reed and S. Lansley (2016), *Universal Basic Income: An idea whose time has come?*, A. Sperrmann (2006), *Basic Income Reform in Germany: Better Gradualism than Cold Turkey*; M. Sommer (2016), *A Feasible Basic Income Scheme for Germany*; B. István et al. (2014), *A Lét:ajánlat a magyar társadalomnak.*

Significant benefit entitlements among higher-income groups are a result of making social-insurance benefits and pensions available to a sizeable share of working-age individuals (e.g., in France, see notes to **Figure 1**, and in Southern European countries).

Rapidly evolving labour markets are blurring lines between traditional employment and different forms of independent work. New types of atypical employment also make it harder to reliably assess whether someone is working at all. As a result, it becomes more difficult to tie social-protection entitlements and contributions to people's employment status. If existing targeting strategies do not provide adequate coverage for all those in need, moving towards greater universality is one option for keeping social protection accessible. A BI provides an interesting counterfactual in this debate.

Both supporters and opponents of a BI agree that replacing large parts of existing social protection with a universal payment would be a major change. Before discussing pros and cons of reforms in this direction, this note examines how large a departure a BI would be from traditional approaches of providing cash income support.

The starting point for this thought experiment is a hypothetical universal BI that would be paid to all individuals at or below working age (e.g., younger than 65, depending on the country). Such a BI would not directly affect the incomes of people above normal retirement age, or the provision of public services, such as health, education, care, or other in-kind supports. But the BI would likely change the living standards for large parts of the population. It would be financed by abolishing most existing types of cash benefits and tax-free allowances (including social insurance and family benefits but retaining some benefits intended to compensate costs related to special needs, such as disability and cash housing support), and by making the BI itself taxable. The scenarios were chosen to illustrate key mechanics and trade-offs of BI reforms in a comparative context.[1]

1. In practice, extending benefit coverage may have implications for access to services, notably in countries where benefit recipients are covered by health insurance, but those without employment or benefit entitlements are not.

What would be a realistic basic income amount?

One budgetary neutral way of implementing a BI for the working-age population and children would be to take existing spending on benefits for this age group, and to spread it out equally, as a flat-rate amount. The resulting BI amount would be received by everybody, including high-income groups, and would be very much lower than the poverty line of a single individual. In other words, without any additional taxes, a budget-neutral BI will be very far from eradicating poverty, and a BI set at the poverty line would be very expensive (**Figure 2**).

A less ambitious alternative may be to use the levels of guaranteed minimum-income benefits (GMI) in existing social protection system as a target value for a BI. Figure 2 shows that the income provided by GMI is typically well below the poverty line. But in most countries, a BI financed exclusively by replacing existing cash transfers would fall well short even of these lower GMI amounts.

As a result, a single person without any other resources may be significantly worse off with an expenditure-neutral BI, than under existing benefit provisions. Those currently entitled to additional support to compensate for specific needs or circumstances – such as the costs related to a disability or of renting suitable accommodation – would lose out even more from a flat-rate BI. For a BI reform to be realistic, some targeted cash transfers, for instance disability or housing benefits, may therefore need to be kept alongside the BI.

But this would require even greater reductions of BI amounts if expenditures are to be kept at current levels. A BI at socially and politically meaningful levels would therefore likely require additional benefit expenditures, and thus higher tax revenues to finance them. By taxing the BI alongside other incomes, its net value would fall, reducing its cost and making it more targeted to lower-income groups, who pay lower tax rates.

A further option for financing a BI is to abolish any existing tax-free allowances. This option is commonly included in BI proposals, as the rationale for allowing individuals to keep a portion of their income tax-free becomes less convincing when everyone receives a minimum level of income. Moreover, unlike means-tested benefits, a BI does not get withdrawn when people start earning more. Work incentives would be stronger as a result, and tax-free allowances could be abolished, while still lowering marginal effective tax rates for many low-income earners (typically the group most likely to work more in response to stronger incentives).

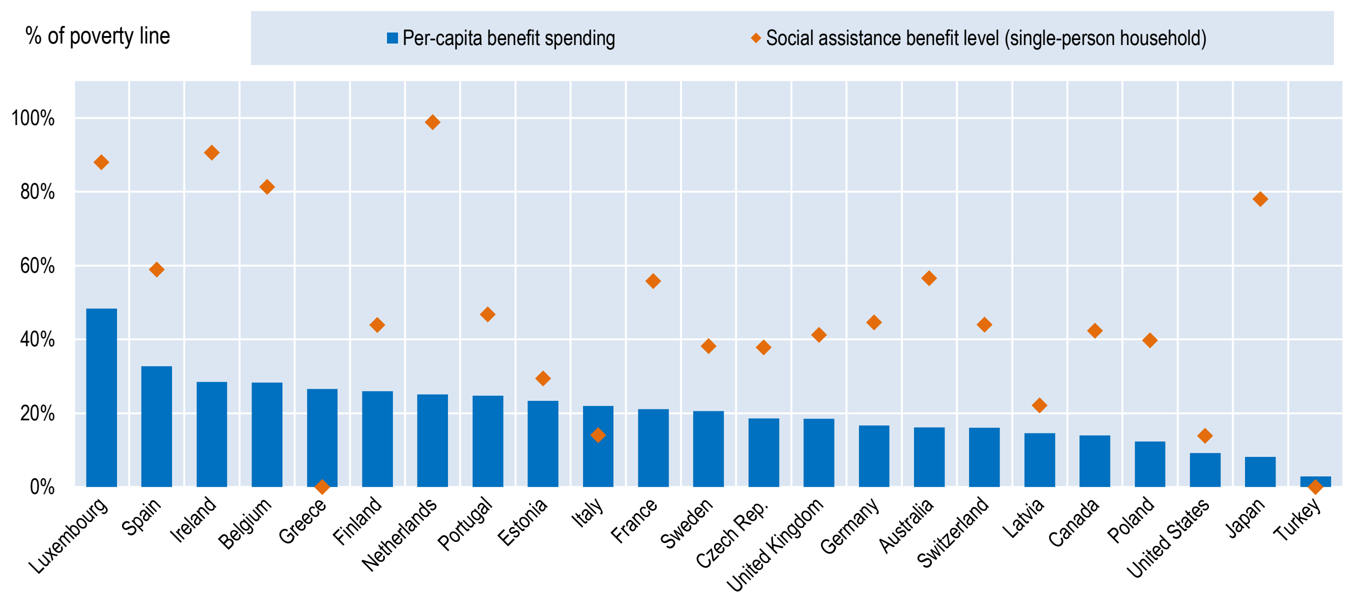
Financing the costs

More detailed simulations of a hypothetical universal BI reform show that, in some countries, a BI that is paid at current GMI levels could result in budget savings. (**Box 2** summarises the reform parameters that were chosen for the policy simulations.)

This is the case in Finland and Italy, if the BI replaces most existing working-age benefits, if it is taxed alongside other incomes, and if zero-rate tax bands or tax-free allowances are abolished, and all income-tax thresholds are shifted downwards by a corresponding amount. Any resulting surplus revenue could then be used to finance a more generous BI amount, or to reduce income taxes (e.g., by lowering tax rates). In France, additional revenues from abolishing tax-free allowances would also almost offset the additional cost of a BI set at GMI levels: a budget-neutral reform would then require only a small reduction in the BI level below GMI levels, or a small further tax rise.

Figure 2. At current spending levels, a basic income would be well below the poverty line

Non-elderly benefit spending per capita and guaranteed minimum income (GMI) level as a percentage of the poverty line, 2013



Note: Poverty thresholds are 50% of median disposable household income. Per-capita spending is in gross terms and refers to total cash transfer except old-age and survivor pensions, but including early-retirement benefits where these can be identified, divided by the number of residents aged below 65 (62 in France). Where receipt of old-age pensions among working-age individuals is relatively common (e.g. in France), true per-capita amounts of all "non-elderly" benefits is significantly higher. Some countries (e.g. Luxembourg) pay significant amounts of benefits to non-residents; dividing total expenditure by the resident populations only overestimates true per-capita amounts in these cases. Social assistance amounts refer to the main means-tested safety-net benefit available for working-age people and do not include cash housing benefits that may be available separately. No nationally applicable general GMI entitlements existed in Greece and Turkey. Social Assistance in Italy refers to the *Sostegno per l'inclusione attiva* GMI programme that started being rolled out nationally in 2016; no nationally applicable GMI programme existed prior to that.

Source: OECD Social Expenditure, Income Distribution, and Tax-Benefit Policy database.

Box 2. Basic Income: From general concept to concrete policy scenarios

Analysing hypothetical policy scenarios requires choosing a wide range of reform parameters. The main ones adopted for the purpose of this note are as follows and are used for policy simulations in four countries, Finland, France, Italy and the United Kingdom:

1. Individuals receive the BI if they reside in the country and are below the current main statutory retirement age: younger than 65 in Finland and Italy, younger than 65 (men) or 62 (women) in the United Kingdom, and younger than 62 in France.

2. The BI is modelled as an individual entitlement. All adults receive the same benefit amount before tax. The BI is also the same for all children, but different from the adults amount. The after-tax BI for adults is initially scaled to match GMI levels for single individuals. Amounts for children are then set so that a family with two children and no earnings receives the same income as before the reform. In households that include both working-age and older adults, the incomes of older individuals are protected (i.e., their benefits and taxes are unchanged by the reform).

3. Cash support for rented accommodation is retained (but amounts may change once recipients start receiving a BI, as a result of any built-in means tests). Disability benefits exceeding BI levels are reduced by the amount of the BI. All other cash benefits (unemployment, GMI, family, early retirement, and in-work benefits) are abolished. The BI reform does not directly affect any services or other in-kind support provided by existing social protection systems. All existing social contributions are kept in place, but no contributions are levied on the BI (and BI receipt does not create entitlement to later old-age pension or other insurance benefits).

4. All BI amounts are made fully taxable under personal income tax alongside other taxable income, so the net BI is smaller for higher-income tax payers. In addition, zero-rate tax bands of income-tax schedules (as well as equivalent tax-free allowances) are abolished, all income-tax brackets are shifted downwards by the amount of the zero-rate band (rather than, e.g., expanding the width of the bottom bracket only and keeping other tax-band limits unchanged).

All headline results refer to budget-neutral scenarios. Budget neutrality is achieved by adjusting BI amounts either above or below GMI levels, depending on whether or not the cost of a BI at GMI level exceeds the budget gains from abolishing non-BI benefits (3) and from higher tax revenues (4). No account is taken for any reductions in administrative costs following a replacement of existing benefits with a much simpler BI.

All results are derived for unchanged employment, working hours and earnings, i.e., the simulations do not consider any short-term or longer-term behavioural responses to the BI reform.

Unless otherwise noted, budgetary and distributional consequences of BI scenarios are evaluated relative to the tax-benefit policy rules that were in place in 2015. The simulations are carried out using EUROMOD, the tax-benefit model for the European Union. For full details and results, see the technical background note cited under “Further reading” at the end of this note. Results presented in this note make use of EUROMOD version G3.0+.*

* EUROMOD is maintained, developed and managed by the Institute for Social and Economic Research (ISER) at the University of Essex, in collaboration with national teams from the EU member states. We are indebted to the many people who have contributed to the development of EUROMOD. The process of extending and updating EUROMOD is financially supported by the European Union Programme for Employment and Social Innovation “Easi” (2014-2020). Data sources for EUROMOD results reported in this note are as follows. Finland: microdata from the EU Statistics on Incomes and Living Conditions (EU-SILC) made available by Eurostat (59/2013-EU-SILCLFS); France and Italy: national EU-SILC PDB data made available by respective national statistical offices; United Kingdom: Family Resources Survey data made available by the Department of Work and Pensions via the UK Data Archive. None of the individuals or organisations mentioned in this acknowledgement are responsible for the analysis or interpretation of the data reported here.

By contrast, in the United Kingdom, the cost of a BI at GMI levels would significantly exceed current spending on cash benefits and tax-free allowances. A budget-neutral BI reform in the United Kingdom would require a more sizeable reduction of the BI amount below GMI levels, or additional tax increases.

The remainder of this note focuses on a scenario where the BI is financed as described and the BI amount is then scaled up or down to achieve full budget neutrality. The resulting budget-neutral BI amounts, net of tax, are shown in **Table 1.**[2]

In all cases, large tax-revenue changes are needed to finance a BI at meaningful levels, and tax reforms would therefore need to be an integral part of budget-neutral BI proposals. Even when headline tax rates remain unchanged, abolishing tax-free allowances and making BI taxable means that everybody would pay income taxes on the BI, and on all their other income. Tax burdens would go up for most people as a result, further increasing tax-to-GDP ratios that are currently already at a record-high in the OECD area. In Finland and the United Kingdom, the additional tax revenue would contribute a significantly larger share of gross BI expenditures (60% and 68%, respectively) than the savings from abolishing or reducing existing benefits and in France, higher tax revenues would contribute around half (51%) of gross BI expenditure. In Italy, higher tax payments would represent a lower share of BI spending (28%) but the implied increase in tax revenues would still be large.

Table 1. Monthly BI amounts that would cost the same as existing benefits and tax-free allowances

	Adult	Child (<18)	Poverty line for single person
Finland	EUR 527	EUR 316	EUR 1074
France	EUR 456	EUR 100	EUR 909
Italy	EUR 158	EUR 158	EUR 737
United Kingdom	GBP 230	GBP 189	GBP 702

Note: Hypothetical reform where a basic income would replace most existing working-age benefits, as well as the tax-free allowance. See Box 2 for details. BI amounts are shown after tax and are 9% higher than existing single-person GMI in Finland and as much as 97% higher in Italy. In France, the budget-neutral BI amount would be 2% below current GMI levels and in the United Kingdom, the budgetary neutral BI amount would be 28% below current GMI levels. Poverty line is 50% of median household income adjusted for household size using square root of household size.

Source: Secretariat calculations using EUROMOD.

2. If BI were, instead, kept at GMI levels, budget neutrality could be achieved by raising (all) personal income-tax rates by 2% in France and 25% in the UK, while tax rates could be reduced by 5% in Finland and by 31% in Italy. In Italy, revenues from income tax and social contributions would be 13% lower as a result. But in Finland (+57%), abolishing tax-free allowances and making BI taxable means that revenues would be much higher than before the reform even with these tax-rate reductions. In France, the combination of a small increase in tax rates and the abolition of tax-free allowances increases income tax revenues by 44% and in the UK, the increased tax rates in such a scenario would nearly double revenues from income tax and social contributions (+95%).

Gainers and losers of a comprehensive basic income

A universal BI is very simple. But since existing social benefits are not, replacing them with a universal flat-rate benefit produces complex patterns of gains and losses. A budget-neutral BI reform would therefore not be distributionally neutral. **Box 3** summarises the factors driving income in different types of households.

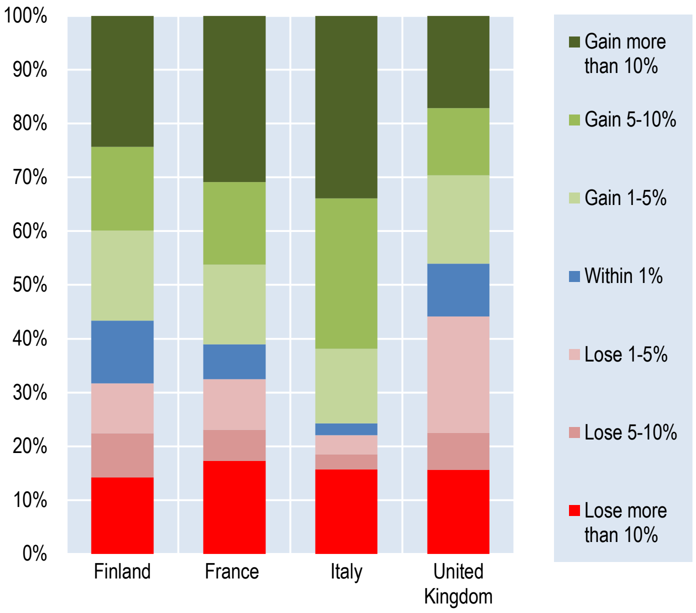
Overall, a large majority would see either significant gains or large losses (**Figure 3**). This is most pronounced in France and Italy, countries where the benefits that a BI would replace are largely based on social insurance. Those receiving social insurance benefits (e.g. early retirees, and many unemployed) would normally lose out from their replacement with a BI at GMI levels. Because early retirement pensions are only received by those approaching retirement age, losses are especially frequent in the 55-64 age bracket (**Figure 4**).

Benefit recipients losing out from a BI reform in France and Italy may belong to different income groups, which is one reason why the proportion of households losing from this type of BI reform can be roughly the same at very different income levels (**Figure 5**). Those not qualifying for any social benefit under existing policies (or not taking it up) gain if the BI exceeds the increase in their tax burden, and lose otherwise. Because of very low benefit coverage in Italy, a large majority of individuals in all income groups would benefit from a BI. In France, many of the losses of higher-income households are driven by the tax changes accompanying the hypothetical BI reform (notably the removal of the zero-tax band).

In France, and to a lesser extent in Finland and the United Kingdom, income gains are most common in middle-income households – they do not qualify for means-tested benefits under existing systems, but do receive the BI after a reform. They also lose less from the abolition of tax free allowances than higher-income households.

Figure 3. Few people would see their incomes unaffected by a basic income

Gainers and loser, in % of individuals in working-age households



Note: Working-age households are those with at least one working-age individual. Hypothetical budget-neutral reform where a basic income would replace most existing working-age benefits, as well as the main tax-free allowance. See main text and Box 2 for details.

Source: Secretariat calculations using EUROMOD.

Lower-income households are more likely to receive means-tested income support and therefore less likely to gain as the BI is set at similar levels to GMI. A result specific to the United Kingdom is the higher share of gainers in the lowest-income group than in the groups with slightly higher incomes. One reason is the significant non-take up of means-tested benefits: as a result, a substantial number of poor families not currently covered by means-tested benefits would gain from a universal BI.

Box 3. Gainers and losers by family type

For single-person households, setting the BI amount at GMI levels would leave incomes for those with very low incomes, and entitled to GMI under current policies, largely unchanged.[1] Calculations with the OECD tax-benefit models show that in some countries, including Finland and the United Kingdom, single people with higher incomes would also be broadly unaffected.[2] In France, tax allowances are worth more than the BI amount for those earning above the average wage. Higher-income earners would therefore often lose incomes overall.

The impact of a BI reform would be far bigger for other family types, however. The individualised nature of the BI cannot adequately replicate the levels of support that existing social protection systems provide to different family types. For example, GMI amounts for couples in most existing GMI systems are less than twice the single-person amount in reflection of the economies of scale resulting from couples living together. Many couples without children would consequently gain from a BI set at single-person GMI. Higher-income families with children would gain if existing support for families with children is, in part, targeted to lower-income families.

By contrast, lone parents at lower income levels may lose out, as a fully individualised BI would fail to provide extra support to parents living without a partner, which is often available in existing social protection systems.

1. Any difference would come from making the BI taxable, and from adjusting its level to make the reform budget neutral.

2. Essentially, this is because the value of GMI benefits is approximately the same as the combined value of tax-free allowances and in-work benefits for a single person. A full set of calculations is reported in the background paper referenced in Box 2.

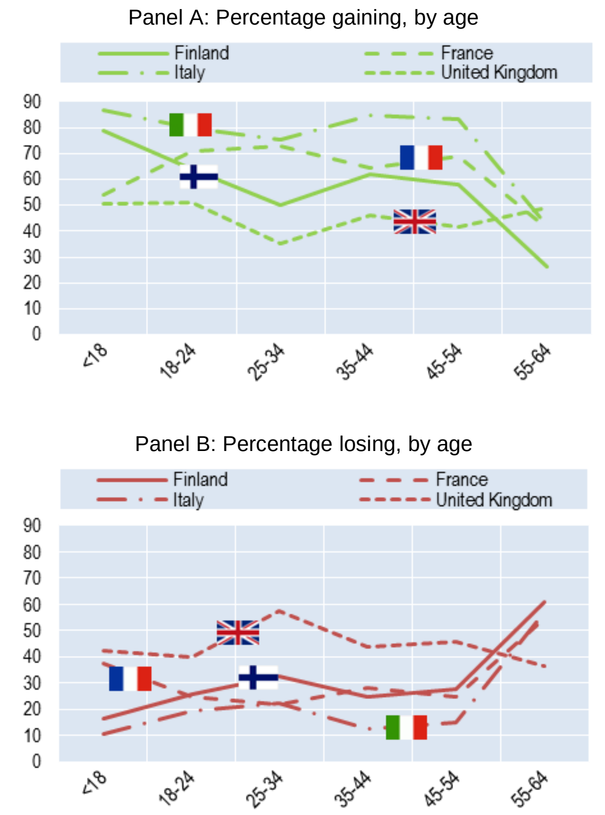
Would a basic income reduce poverty?

Many poor would see income gains if they are not covered by existing social protection or they only receive small amounts of means-tested benefits. But some others, notably those currently in receipt of more generous support, would fall below the poverty line. As shown in Figure 1, benefit recipients do not necessarily live in the lowest-income households. But if they rely exclusively on benefits (e.g., some unemployed and early retirees), they would see very significant income reductions – and would fall into poverty when BI amounts are set below poverty thresholds (as is the case here).

The net effect of gains and losses would be large shifts in the composition of the income-poor, with some people moving above the poverty line (taken here as 50% of median household income), while others would fall below it (**Table 2**). Overall poverty rates (and gaps) can in fact increase significantly in countries that currently have tightly targeted systems of income support (**Figure 6**). The relatively good benefit coverage of income-poor households in France and Finland means that income gains from a BI are also not sufficiently widespread among low-income households to reduce poverty headcounts overall. In Italy, poverty headcounts change little overall, as reductions in poverty among those not covered by existing benefits are offset by the greater poverty risks resulting from the large losses of current benefit recipients.

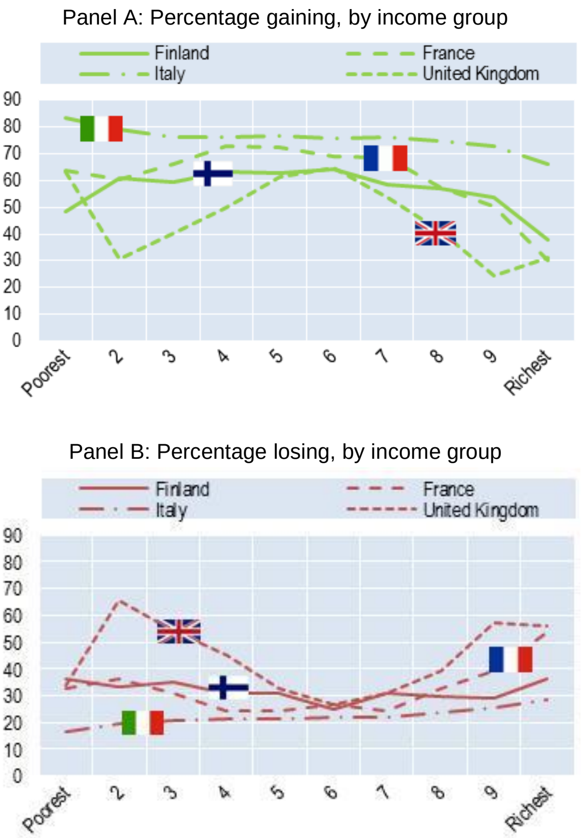
Unlike in the other countries, the budget-neutral BI amount in the United Kingdom is below GMI levels, and poverty rates would increase significantly as a result. Different reform parameters, e.g., combining higher BI levels with (further) tax increases could avoid some of the losses. But one message emerging from the results is that a BI is not necessarily an effective poverty-alleviation tool, even if it would provide improved support to those who are not currently covered by social benefit provisions.

Figure 4. Early retirees would lose out when existing benefits are replaced with a modest BI



Note and Source: See Figure 3. Gains and losses each refer to income changes of 1% or more.

Figure 5. Low-income households currently receiving a benefit would often be worse off under a BI



Note and Source as in Figure 4.

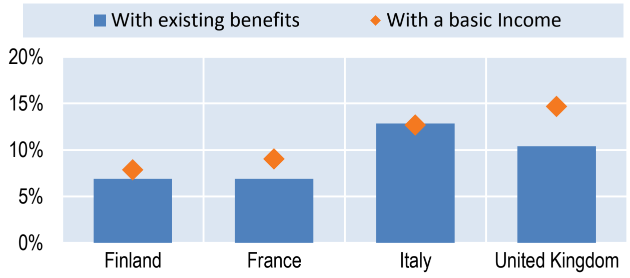
Table 2. A comprehensive basic income would change the distribution of poverty risks …

		In poverty under basic income?			
		No		Yes	
In poverty under existing system?	No	UK: 83% France: 89%	Finland: 90% Italy: 83%	UK: 7% France: 5%	Finland: 3% Italy: 4%
	Yes	UK: 2% France: 2%	Finland: 2% Italy: 4%	UK: 8% France: 4%	Finland: 5% Italy: 9%

Note and Source: See Figure 3. Poverty line is 50% of median household income adjusted for household size using square root of household size. Cells shaded in green (red) show shares of people moving out of (into) poverty following the BI reform.

Figure 6. … but it would often not lower poverty overall

Poverty rates under existing systems, and a BI



Note and Source: See Figure 3 and Table 2. Poverty rates are relative to the number of people living in working-age households.

Simple, but not without problems

BI proponents point to its administrative simplicity, and to its role in providing a degree of income security in fast-changing labour markets. A modest "permanent" income would also provide individuals with greater flexibility for managing work, family and other responsibilities or interests. As such, it could facilitate activities that have attractive payoffs for society but can be costly, time-consuming, or risky for individuals, such as caring, volunteering, social entrepreneurship, education, training or internships, or starting a business.

An unconditional benefit also avoids the social and economic costs of complex means tests or other elaborate conditions for benefit receipt. Such conditions are necessary in social protection systems that seek to channel support to those in specific situations of need (so-called "contingencies"), such as ill-health, unemployment, childbirth or family dissolution. But they can create incentives for arranging one's affairs in ways that maximise benefit entitlements (e.g., by working less or informally, or by living separately rather than together), causing individual or social costs in the process. Strict monitoring and enforcement of entitlement conditions help to eliminate illicit receipt of support, but they are also associated with administrative costs and stigma, which reduces benefit take-up among intended recipients.

There are also major concerns about unintended consequences of a BI. An especially prominent one is that unconditional income support would reduce the necessity for paid work and work incentives. For some jobs and workers, a modest BI may indeed reduce the willingness to work at prevailing wage levels (and, hence, strengthen workers' bargaining position to demand better working conditions). But a revenue-neutral BI would not change incomes on average. While those gaining from it may work a little less, those losing out may work more and the net effect would be small.

Moreover, adverse incentive effects of social benefits are also a prominent concern in the context of existing social protection systems. Indeed, benefits that are withdrawn when people start a new job or increase their earnings do more to weaken work incentives than a BI. Simulations reported in the companion technical background note show that the additional tax burdens needed to finance a BI can reduce work incentives for households that already have significant work income, notably for second earners. However, incentives to work at all would be significantly stronger with a BI, especially for lower-income households, who tend to react most strongly to work incentives.

Nonetheless, an entirely unconditional BI would sever links between carefully balanced rights and responsibilities of job seekers. A key element of existing policies to promote the prompt (re)integration of job seekers into employment (activation strategies), for instance, is that benefits and employment support are tied to active participation in job-search and labour-market integration measures.[3] Targeting these incentives and services to job seekers would become more difficult if everyone is a benefit recipient and benefit conditionality is no longer there.

Relaxing links between benefit entitlements and the behaviour of recipients would in fact represent a notable departure from key principles of "active" social and employment policy in large parts of the OECD, and this is a key challenge that proponents of a comprehensive BI have to confront. In response, some have proposed "less universal" versions of a BI that would keep elements of a "rights and responsibilities" nexus intact. A prominent proposal along these lines is the "participation income" (Atkinson, 1996; 2015).[4] Like a BI, the participation income would be independent of income or family situation, but would only be paid to individuals who are either in paid work, are looking for a job, or are engaged in other socially useful activities (e.g. caring, volunteering, education, or training).[5]

There are other criticisms of using a BI as a principal pillar of social protection. Many of them are plausible and justified, even if some of them are also frequently noted as problems with more traditional forms of income support. For instance, paying income support to middle and higher-income groups, and charging them taxes to finance it, can be inefficient as it amounts to "giving with one hand and taking with the other". But, as shown in Figure 1, even without a BI, a number of countries, including in parts of Southern and Eastern Europe, pay large shares of benefits to higher-income households. Replacing existing benefits with a uniform BI may therefore reduce support to the rich in some cases.

Likewise, a BI may alter the balance in wage negotiations and there are concerns that it might lead to attempts by employers to reduce wages in response. However, as shown in this note, taxes would increase as well and as long as the reform is budgetary neutral, there would be no net benefit on aggregate making such attempts by employers more difficult. Moreover, similar concerns are relevant also for existing support programmes, notably in-work benefits, and they can be addressed through measures that conserve an adequate representation and bargaining power of low-wage workers (e.g., through statutory or collectively agreed minimum wages). Indeed, proponents of a BI argue that it would play a major role in ensuring adequate remuneration, by giving workers a better "outside option" that would allow them to reject low-paid employment.

From a broader economic-policy perspective, a potential downside of a BI is that, unlike unemployment support or means-tested benefits, it does not act as an automatic stabiliser: since it is paid regardless of income or employment status, spending levels do not go up during a downturn.

3. H. Immervoll and S. Scarpetta (2012), "Activation and Employment Support Policies in OECD Countries. An overview of current approaches", *IZA Journal of Labour Policy*, Vol. 1(9).

4. A.B. Atkinson (1996), "The Case for a Participation Income", *The Political Quarterly*, Vol. 67(1).

5. In line with work and job-search requirements for recipients of out-of-work benefits in existing social protection systems, exemptions from these conditions might apply to those who are sick or disabled.

What role for BI in making social protection more accessible? Options and drawbacks

As shown by the simple simulations presented in this note, converting all or most existing income supports into a flat-rate, "no questions asked" transfer at modest levels would require substantial additional tax revenues. Even then, a BI may result in losses for substantial parts of the population, and would not significantly reduce poverty from existing levels. The large additional tax revenues that would be required, and the sizeable number of people facing large losses, including among "deserving" social groups targeted by existing income support systems, are among the most immediate obstacles to a large-scale BI reform.

Increasing BI rates to levels that avoid large-scale losses would create additional financing challenges. In addition, more generous BI would likely intensify concerns about unintended consequences of a BI, notably the possibility that some people may work significantly less.

In this context, are there intermediate forms of support that would adopt key aspects of a comprehensive BI but avoid some of its drawbacks?

Introducing a BI while leaving important existing benefits (such as early retirement pensions) in place would limit losses among current benefit recipients. But, at unchanged BI levels, such a reform would also cost much more than the scenarios considered in this note and require a determined effort to broaden the revenue base for financing social protection. Lowering BI amounts to levels substantially below GMI standards, while leaving larger parts of existing benefits in place, may be fiscally more realistic and would make existing social protection more universal. But the BI would then no longer provide significant income protection on its own and it would therefore not represent a complete solution to coverage problems arising with current social protection strategies. A modest BI could nevertheless be desirable if the main aim of such a reform was to more equally share the benefits of globalisation or technological progress, rather than addressing current or future gaps in existing income protection systems.. A gradual move towards greater universality may also be desirable in countries where poorer population groups receive relatively small shares of overall benefit expenditures.

Another alternative would be to keep mild eligibility conditions in place (as in Atkinson's Participation Income proposal). This could lower costs by reducing recipient numbers rather than benefit amounts. But the reductions would only be substantial if eligibility conditions were quite strong, in which case the partial BI would become more difficult to distinguish from traditional forms of income support.

Recipient numbers could be cut more significantly if the durations of BI payments were capped, e.g., at a certain number of years during anyone's lifetime. This type of BI, which could be financed through one-time grants or recurring individual or state contributions, might resemble some aspects of individual accounts, such as those used for administering unemployment benefits in Chile. But compared with existing forms of income support, the ambition of a time-limited BI could be to provide individuals with much greater autonomy in terms of how and when to make withdrawals from these accounts.

A further option for reducing BI recipient numbers, at least initially, could be to introduce it gradually to different groups. For instance, BI entitlements could be rolled out to successive future cohorts of young adults. Since these cohorts would not yet be receiving any other out-of-work benefits, the risk of income losses would be minimal even if the BI were to fully replace existing social protection provisions for successive cohorts.

The basic income shines a spotlight on the challenges, but also on the strengths, of existing social protection systems. A comprehensive BI would represent a major and, to date, largely untested departure from traditional forms of social provisions that would require very determined social and fiscal policy efforts, and would produce both gainers and losers. It is not a one-size-fits-all solution for current and future challenges facing social policy. In view of rapid changes in the labour market the ongoing discussions of BI options do, however, provide a valuable impetus for much-needed debates about the type of social protection that societies want, and for the search of reform options that are socially and politically feasible.

Further reading

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Note

The statistical data for Israel are supplied by and under the responsibility of the relevant Israeli authorities. The use of such data by the OECD is without prejudice to the status of the Golan Heights, East Jerusalem and Israeli settlements in the West Bank under the terms of international law.

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This policy brief, the technical background note, as well as all figures and underlying data can be downloaded from www.oecd.org/employment/future-of-work.htm.

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OECD
BETTER POLICIES FOR BETTER LIVES

Skills for a Digital World

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Information and communication technologies (ICT) are profoundly changing the skill profile of jobs. Skill development policies need to be overhauled to reduce the risk of increased unemployment and growing inequality.

To thrive in the digital economy, ICT skills will not be enough and other complementary skills will be needed, ranging from good literacy and numeracy skills through to the right socio-emotional skills to work collaboratively and flexibly.

56% of the adult population have no ICT skills or have only the skills necessary to fulfil the simplest set of tasks in a technology-rich environment. Young people, however, are much more ICT proficient than older generations.

Skills policies should seek to: strengthen initial learning; anticipate and respond better to changing skill needs; increase the use of workers' skills; and improve incentives for further learning.

What skills for tomorrow's digital world

Ensuring that everyone has the right skills for an increasingly digital and globalised world is essential to promote inclusive labour markets and to spur innovation, productivity and growth. Several types of skills are needed: technical and professional skills, including ICT specialist skills for workers who drive innovation and to support digital infrastructures and the functioning of the digital eco-system; ICT generic skills for workers and citizens alike to be able to use digital technologies; and ICT complementary "soft" skills, such as leadership, communication and teamwork skills, required for the expanding number of opportunities for ICT-enabled collaborative work (OECD, 2015a; OECD, 2016a; Grundke et al., 2017).

The use of ICT in the workplace – affecting only a handful of occupations a few decades ago – is now required in all but two occupations in the United States: dishwashing and food cooking. (Berger and Frey, 2016). Similarly, in most OECD countries, over 95% of workers in large businesses and 85% in medium-sized businesses have access to and use the Internet as part of their jobs. In small businesses the share is at least 65% (OECD, 2013). Workers will thus have to be able to take on complex, less automatable, tasks such as problem solving in novel situations while working with the new technologies. This requires solid literacy, numeracy and problem-solving skills, but also autonomy, co-ordination and collaborative skills which complement ICT skills (OECD, 2015a). Workers also need to be capable of adapting continuously as technologies evolve (Spitz-Oener, 2006; Bessen, 2015).

According to OECD estimates, less than 10% of workers, on average in the OECD area, are in jobs that are at risk of being replaced by machines, but 25% are in jobs where a high percentage of tasks (50-70%) could be automated (Arntz et al., 2016). This underlines the need for flexible skills that allow workers to shift to new tasks that are difficult to automate.

Digitalisation is accelerating the pace of globalisation, helping firms increase their competitiveness. In turn, globalisation and offshoring change the distribution of job tasks globally. As a result, German workers today, for example, compared to those in the 1970s, must have a more varied skill set enabling them to perform multiple tasks rather than one specific task (Becker and Muendler, 2015).

Not only the workplace is changing; interactions between public and social services and business and clients are also relying increasingly on digital, mobile or social-media tools (OECD, 2009, 2011). For example, the Flemish public employment service (VDAB) uses the matching capabilities of mobile apps in providing services to jobseekers, and the Dutch public employment service (UWV) has digitised most of its functions to improve efficiency (OECD, 2015b).

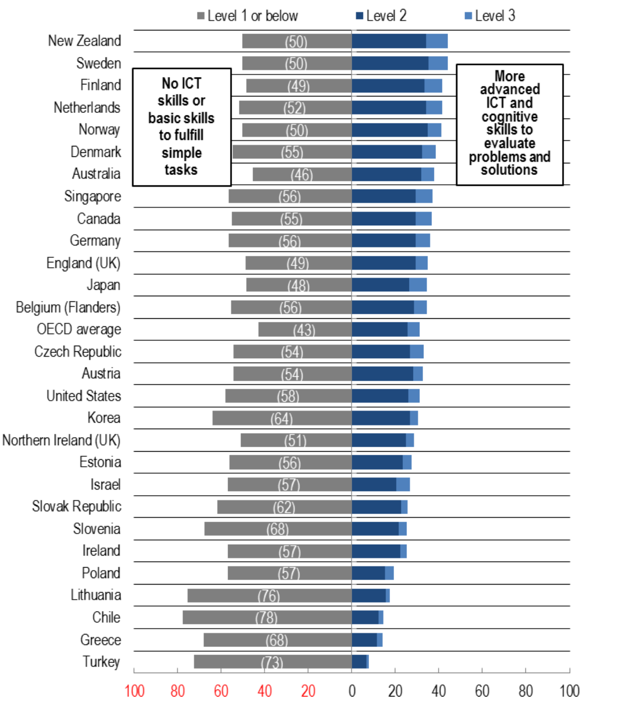
Are workers ready for a digital world?

In an increasingly digital world where the skill needs of employers are continuously evolving, policy makers need to make sure that everyone can participate and learn new skills. Recent technological change has shifted skill demands predominantly towards high-level skills. Workers need to be prepared to change jobs over their working life while avoiding unemployment or ending up in a lower paying job. ICT foundation skills are becoming increasingly important in order to benefit from technological innovation in terms of better employment chances and higher wages.

The evidence on how well countries are prepared for the digital economy is rather disturbing. The OECD's Survey of Adult Skills (PIAAC) suggests that more than 50% of the adult population on average in 28 OECD countries can only carry out the simplest set of computer tasks, such as writing an email and browsing the web, or have no ICT skills at all (see Figure 1). Only around a third of workers have more advanced cognitive skills that enable them to evaluate problems and find solutions (OECD, 2013). As a result, many workers use ICTs regularly without adequate ICT skills: on average, over 40% of those using software at work every day do not have the skills required to use digital technologies effectively (OECD, 2016a).

Figure 1. The majority of adults have low proficiency in problem solving in technology-rich environments

Percentage of 16-65 year-olds performing in each proficiency level



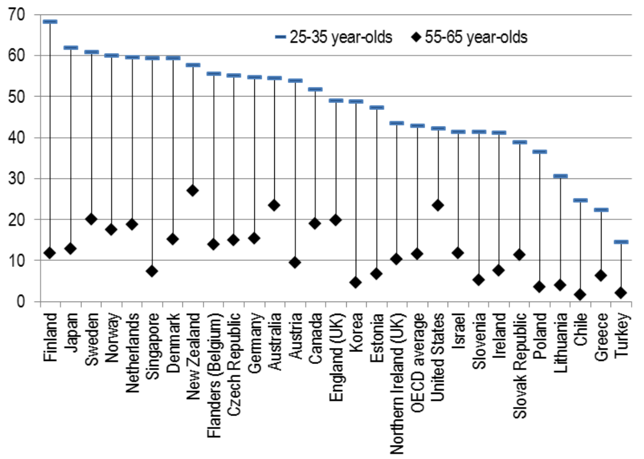
Notes: Individuals in Level 2 or Level 3 have more advanced ICT and cognitive skills to evaluate problems and solutions than those in Level 1 or below.
Source: OECD (2015c), Survey of Adult Skills (PIAAC) 2015.

Not surprisingly, younger generations do better than older people (Figure 2). Some 42% of adults aged 25 to 34 can complete tasks involving multiple steps and requiring the use of specific technology applications, such as a new online form (Level 2 or 3), but in the age group 55-65, only one in ten can do so.

Although most young people seem ready to interact with technology, there is still a large share of youth with low levels of proficiency. Moreover, the unequal distribution of ICT skills by educational attainment and migrant status may also amplify existing inequalities as these skills become increasingly important.

Figure 2. Younger people are better prepared for the digital working environment than older people

Share of 25-34 and 55-64 year-olds performing at Level 2 or 3 in Problem Solving in Technology-Rich Environments



Source: OECD (2015c), Survey of Adult Skills (PIAAC) 2015.

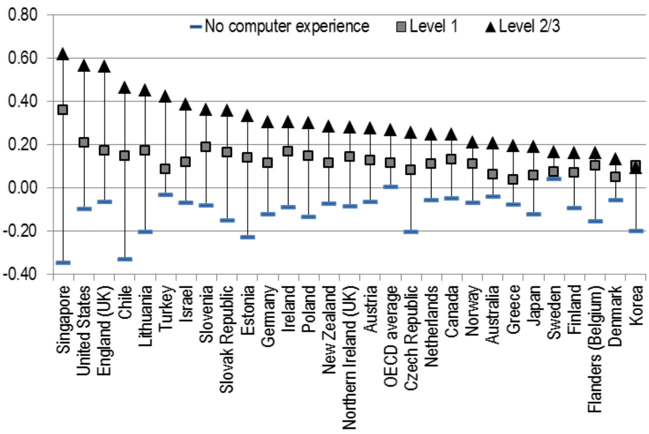
There is no sizeable gender gap in the share of people possessing good ICT generic skills – i.e. those who perform at the medium and high level in problem solving in technology-rich environments. However, a sizeable gap emerges when focusing only on ICT specialists. In 2014, 5.5% of male workers in OECD countries were ICT specialists compared to just 1.4% of female workers (OECD, 2016a). While this is a relatively small group, it involves well-paid jobs in high demand and with good career prospects.

The importance of digital skills is reflected in the wage returns to these skills (see Figure 3 or Falck, Heimisch and Wiederhold, 2016). Compared to workers who can only perform the most basic computer functions like typing or operating a mouse (workers at or below Level 1), workers performing at Level 2 or 3 are paid 27% more, on average. These gaps are greater than 50% in England (UK), Singapore and the United States. Workers with no computer experience earn around 10% less than those with the most basic computer skills.

To seize the benefits of technological change, economies need ICT specialists: workers who can code, develop applications, manage networks and manage and analyse Big Data, among other skills. These skills enable innovation in a digital economy to flourish, but also support the infrastructure that firms, governments, commerce and users rely on (OECD, 2015a). However, besides these experts, digitalisation also calls for all workers to have a relatively high minimum level of ICT skills, even those in low-skilled jobs. For instance, this is the case for blue-collar workers in factories that are entirely automated or waiters having to take orders on iPads.

Figure 3. There are strong returns to problem-solving skills in technology-rich environments

Wage premium compared to workers performing at or below Level 1 in Problem Solving in Technology-Rich Environments



Source: OECD (2015c), Survey of Adult Skills (PIAAC) 2015.

Jobs requiring more intensive ICT use also require a range of technical, professional and other occupation-specific skills, a solid level of information-processing skills (e.g. literacy and numeracy), as well as the ability to collaborate, share information, give presentations, provide advice, work autonomously, manage, influence and solve problems. (OECD, 2015a). As technology automates certain tasks, the value of skills needed for non-automatable tasks, such as social skills, also increases (Autor, 2015; Deming 2015).

Four key priorities for skills policies to meet the challenges of a digital world

Addressing the challenges arising in an increasingly digital world will require an overhaul of current employment and skills policies. Government must help ensure that an increasingly digital world yields better quality jobs and that both employers and workers have the means to take advantage of the new job opportunities that open up. There are four key priorities for skill policies to facilitate take-up of these opportunities and promote inclusive growth:

1) Part of the task is to ensure that initial education equips all students with basic ICT skills as well as solid literacy, numeracy and problem-solving skills to use ICT effectively. Many of these skills are acquired also outside education and training institutions – for instance, in the workplace – emphasising the need to recognise skills acquired outside formal channels.

   For ICT specialist skills, basic programming is no longer enough. For instance, advanced engineering and experience with machine-learning are increasingly important. In addition, ICT specialists also need domain-specific knowledge, given the potential applications of ICT in business, health, education and industry.

2) Education and training systems need to better assess and anticipate changing skill needs in order to adapt programmes and pathways offered and guide students towards choices that lead to good outcomes. Big data can be harnessed to complement labour market information systems and monitor changing needs (OECD, 2016a). By including all stakeholders in skills assessment exercises and in translating the findings into pratice, governments can ensure that the information collected is useful and that policies respond to actual needs (OECD, 2016b).

3) It is not just sufficient for workers to have the skills needed for the digital economy but employers must fully use these skills to reap their benefits in terms of higher productivity and greater competitiveness. The use of skills, including reading, numeracy and problem solving in a technologically-rich environment, varies substantially across countries (OECD, 2016b). A key factor driving this variation is the use of high performance work practices such as teamwork, work autonomy, training, flexible work hours, etc. Thus it is important to promote better work organisation and management practices within firms and across the economy, as well as fostering the skills needed to support these practices.

4) As skill demands change continuously, training for workers to keep up with new skill requirements is crucial. This requires offering better incentives for workers and firms to re-skill and up-skill. It also means using the possibilities of new technologies to adapt new job tasks to the skills sets of incumbent workers. At the same time, the diffusion of "on-demand" jobs on digital platforms puts increasing responsibility on individuals for managing their own skills development (OECD, 2016c). Low- and medium-skilled workers are the least likely to receive training, even though they may be facing the greatest risk of job loss.

For youth who have dropped out of education and lack the necessary skills, well-designed second-chance programmes can be effective for reintegration. Second-chance programmes promoted by the European Union, or those in Canada, France, Ireland and the United States have a strong focus on basic and complementary ICT skills (OECD, 2015e). More generally, effective and well-targeted active labour market programmes are needed for jobseekers who are facing difficulties because of outdated or inadequate skills.

Digitalisation also opens new opportunities for innovation in learning infrastructure. MOOCs (massive open online courses) and OERs (open educational resources) already offer opportunities to learn for many workers, although still underutilised. Take-up is low due to the low perceived quality of these forms of learning, lack of incentives and lack of recognition of the competencies acquired through these and other informal and non-formal means. To this end, alternative certification methods (e.g. OpenBadge) have begun to appear (ITU, 2014). A number of technology companies such as Microsoft, CISCO, HP, Samsung, Apple, and Google, offer certificates that MOOC participants can earn directly online. Technology also offers prospects of new ways to learn skills, such as using virtual reality, games and so forth.

A combination of policies is needed to allow workers to keep their skills up to date, help them move between jobs and ensure that employers have a skilled, highly productive and innovative workforce. This includes strengthening initial learning, improving incentives for further learning, and reinforcing active labour market programmes for the unemployed (OECD, 2016d). It will also be crucial to tackle skills mismatch and ensure that employers fully use the skills of their workers through management practices that motivate workers and flexible work organisation which allows job content to be adapted or for workers to move to better suited jobs. This would enhance productivity and has the potential for reducing inequality (Adalet McGowan and Andrews, 2015; OECD, 2015b, 2016e).

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POLICY BRIEF ON THE FUTURE OF WORK

Automation and Independent Work in a Digital Economy

May 2016

www.oecd.org/employment/future-of-work.htm

Digitalisation is reducing demand for routine and manual tasks while increasing demand for low- and high-skilled tasks and for problem-solving and interpersonal skills.

Digitalisation raises questions on technology's potential to substitute work. Estimates based on the Survey of Adult Skills (PIAAC) show that on average across countries, 9% of jobs are at high risk of being automated, while for another 25% more jobs, 50% of the tasks will change significantly because of automation.

Digitalisation has opened the ground for new forms of work organisation. Though the 'platform economy' may bring efficiency in matching workers to jobs and tasks, it also raises questions about wages, labour rights and access to social protection for the workers involved

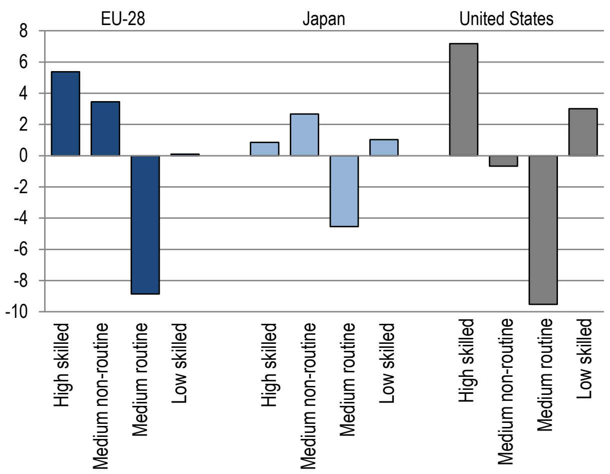
Digitalisation will provide new opportunities to many but will raise challenges for others, with the risk of growing inequalities in access to jobs and their quality and career potential. We need more rather than less policy to allow workers to grasp the new opportunities and respond to the challenges.

Digitalisation is changing the world of work

Demographic shifts, globalisation and new technologies are changing the nature of work and careers. Digitalisation is seen as a key influence on the future of work over the next decades. Ever-increasing computing power, Big Data, the penetration of the Internet, Artificial Intelligence (AI), the Internet-of-Things and online platforms are among developments radically changing prospects for the type of jobs that will be needed in the future and how, where and by whom they will be done. This has sparked a debate about the risk of greater job insecurity, growing inequality and even mass "technological" unemployment.

Figure 1. Job polarisation in the European Union, Japan and the United States

Percentage-point change in employment shares by occupation category, 2002-2014



Source: OECD calculations based on EU-LFS, Japanese Labour Force Survey and BLS Current Population Survey.

Economic history suggests that major innovations such as the steam engine, electricity and the assembly line can be disruptive. They can result in substantial job losses in the short-term, even if this is more than offset in the long-term by the creation of more productive and rewarding jobs with substantial improvements in living standards (Mokyr, Vickers and Ziebarth, 2015; OECD, 2015a). But the lessons of the past may not always apply to the future.

While technological innovation is positively associated with employment in all groups of occupations (OECD, 2015b), artificial intelligence (AI) and digitalisation challenge high-routine jobs (Marcolin et al. 2016). The rapid progress in AI is also raising the prospect that a much broader range of tasks than previously could be carried out by machines. There has already been a hollowing out of jobs involving mid-level skills (Figure 1). Automation has led to the substitution of machines for a substantial part of routine jobs, irrespective of the skill level (OECD, 2013). At the same time, the demand for workers in high-skilled, non-routine jobs has increased considerably in most advanced economies. These jobs often involve tasks such as working with new information, interpersonal skills and solving unstructured problems. Some increase has also occurred in the demand for workers in low-skilled non-routine jobs in activities such as caring and personal services that are hard to automate.

The end result has been a pattern of job polarisation by skill level in many but not all OECD countries (Autor, 2015; Berger and Frey, 2016). It is not clear how these trends will play out in the future, particularly because other structural changes are taking place simultaneously (e.g. globalisation, demographic change, etc.) but there will continue to be a high premium placed on having the cognitive skills to solve non-standard problems.

How many jobs could be replaced?

The idea of 'technological unemployment' was already highlighted by Keynes (1931). Some experts (e.g. Brynjolfsson and McAfee, 2014), suggest that the technological change we are experiencing in this 'second machine age' not only risks displacing some specific types of jobs, but could lead to a decline in overall employment. Not only will routine tasks continue to be automated but cognitive tasks that until recently were considered non-automatable are now at risk, for example, writing standard reports on stock-market changes (OECD, 2015c). Some estimates based on the characteristic tasks of each occupation suggest that almost half of all jobs in the United States and other advanced countries are at risk of being substituted by computers or algorithms within the next 10 to 20 years (e.g. Frey and Osborne, 2013).

Critics of these alarming estimates argue that occupations as a whole are unlikely to be automated as there is great variability in the tasks within each occupation (Autor and Handel, 2013). Two workers holding jobs in the same occupation may not perform the same tasks because their work may be organised differently, one requiring more face-to-face interaction or autonomy, for example. At the same time, within most if not all occupations, tasks have been evolving already for a long time.

A better approach to analysing the number of jobs at risk of automation is to analyse the task content of individual *jobs* instead of the average task content of all jobs in each *occupation*. This results in much lower figures for the share of jobs potentially at risk of automation. On a study commissioned by the OECD and using workers' reports of the tasks involved in their job from the OECD's Survey of Adult Skills (PIAAC), Arntz, Gregory and Zierahn (2016) estimate that just 9% of jobs are at a high risk of being automated on average, ranging from around 12% of jobs in Austria, Germany and Spain to around 6% or less in Finland and Estonia (Figure 2, grey bar). These are jobs for which at least 70% of the tasks are automatable.

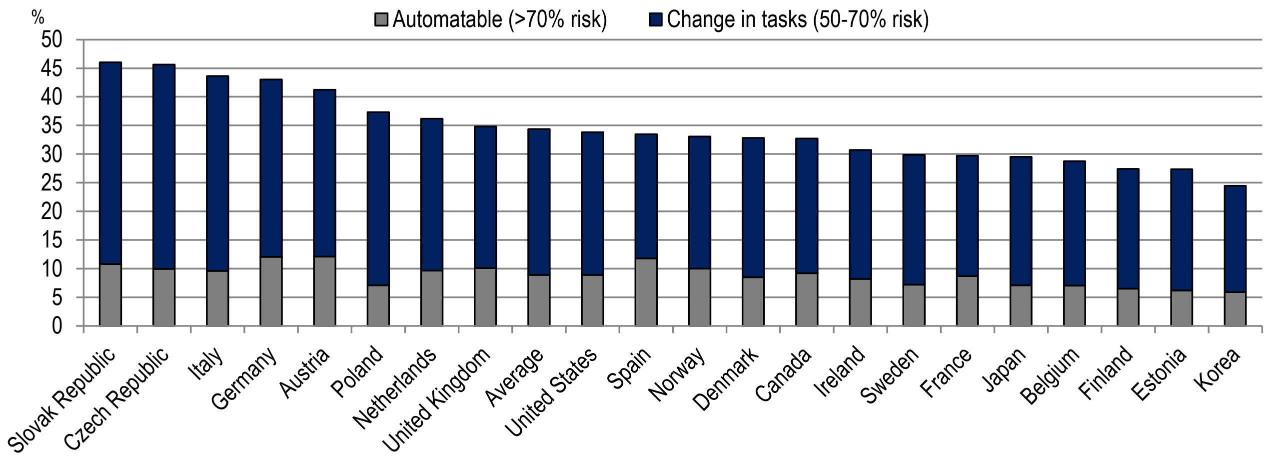
Cross-country differences in the share of workers at high risk of substitution reflect to some extent differences in how work is organised. Countries where jobs rely less on face-to-face interaction are at higher risks of automation. Country differences also reflect the extent to which technology already plays a big role in the economy. Denmark, Japan and Sweden spend a comparatively large percentage of their GDP on ICT investment, signalling that they may well have already automated several tasks or jobs (Arntz, Gregory and Zierahn, 2016).

A larger share of jobs has low risk of complete automation, but an important share (between 50% and 70%) of automatable tasks. These jobs will not be substituted entirely, but a large share of tasks may, radically transforming how these jobs are carried out. These jobs will be significantly retooled and workers will need to adapt (Figure 2, blue bar).

Across all countries, workers with a lower level of education are at the highest risk of displacement. While 40% of workers with a lower secondary degree are in jobs with a high risk of job automation, less than 5% of workers with a tertiary degree are. Thus, automation could reinforce existing disadvantages faced by some workers (Berger and Frey, 2016; Arntz, Gregory and Zierahn, 2016).

Figure 2. The risk of job loss because of automation is less substantial than sometimes claimed but many jobs will see radical change

Percentage of workers in jobs at high and medium risk of automation



Note: Data for the United Kingdom corresponds to England and Northern Ireland. Data for Belgium corresponds to the Flemish Community.

Source: OECD calculations based on the Survey of Adult Skills (PIAAC) (2012) and Arntz, M. T. Gregory and U. Zierahn (2016), "The Risk of Automation for Jobs in OECD Countries: A Comparative Analysis", *OECD Social, Employment and Migration Working Papers*, No. 189, OECD Publishing, Paris.

Technological unemployment?

The risk of extensive technological unemployment can be discounted for several reasons. First, while the number of new jobs directly created by the ICT sector may not fully compensate for jobs displaced elsewhere (Berger and Frey, 2016; OECD, 2015a), new jobs are likely to appear as technological applications develop and other sectors expand as costs fall and income and wealth increase, even if the latter may take some time to materialise. Indeed, some estimates suggest that for each job created by the high-tech industry, around five additional, complementary jobs are created (Moretti, 2010; Goos, Konings and Vandemeyer, 2015).

Second, estimates of job automation typically rely on the theoretical possibility of technology displacing existing jobs, but ignore whether these technologies are actually adopted, which may lead to overestimating the overall impact of technology on the number of jobs in the economy. Indeed the introduction of new technologies is a slow process due to economic, legal and societal hurdles, so that technological substitution often does not take place as expected.

Finally, even if there is less need for labour in a particular country, this may translate into a reduction in the number of hours worked and not necessarily a reduction in the number of jobs. This has been the experience of many European countries over past decades (Spiezia and Vivarelli, 2000).

Even if the risk of technological unemployment can be discounted, job displacement and changes to occupational structure will take place in addition to many jobs being retooled. The magnitude of these changes will vary from country to country, reflecting differences in industry structure, work organisation and the skill mix of the work force. These changes can have an adverse impact on those workers who are not able to make the transition to new jobs. If the labour market polarises even further, some workers may end up stuck in low-skill, low-paying jobs with little possibility of crossing the growing divide into jobs that provide sufficient income and well-being.

Greater work-life flexibility or greater job insecurity?

The Internet facilitates for a more efficient matching between the demand and supply of labour, products and tasks. This creates greater opportunities for workers to enjoy the flexibility and benefits of freelancing, and to top-up their income with additional work in other jobs. Service providers can divide otherwise complex tasks into a set of cheap, routine mini-tasks allocated to workers around the world. This trend has led to the flourishing of the "gig-", "on-demand-", "sharing-" or, more generally, the "platform economy" (AirBnB, Uber, Lyft, Blabla Car, Nubelo, Amazon Mechanical Turk, Task Rabbit, YoupiJob, Frizbiz, etc.) (Spiezia and Gierten, 2016).

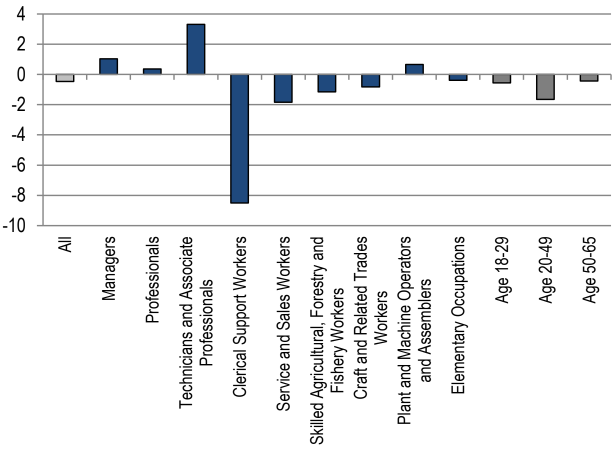
Though still relatively small in scale, the 'platform economy' is largely based on non-standard work arrangements and independent work in particular. Relative to standard wage and salary employment, workers in non-standard jobs tend to have fewer rights to social protection, receive less training, often have weaker career progression, lack access to mortgage and other forms of credit, and face greater insecurity.

It is too early to tell whether this reflects the inherent insecurity of jobs in the platform economy or whether workers who in general are likely to wind up in more precarious jobs tend to be over-represented in these new forms of work. Unfortunately, the employment data that is currently available is not suitable for examining in detail the growth in new forms of work and the extent to which they are associated with greater insecurity.

Available data suggest that between 2011 and 2013 in the EU-28 area, the share of the self-employed among those in employment aged 18 to 64 fell by 0.5% (Figure 3). However, this partly reflects the declining importance of the agriculture sector where the self-employed account for a high share of employment. By occupation, self-employment accounted for a growing share of all jobs among technicians and associate professionals. There are also some differences across countries, with a long-term rise in self-employment as a share of total employment in Germany, the Netherlands and the United Kingdom (France Stratégie, 2015).

Figure 3. Change in the share of self-employment by age and occupation in Europe

Percentage change between 2011 and 2013 in the EU-28 area



Source: OECD calculations based on the EU-LFS.

The most common sources of data on self-employment do not differentiate between independent workers who do independent work as their primary or only activity (freelance business owners, independent contractors), from those that consider themselves freelancers although they are also employees (diversified workers) or from those that had an employer and did some freelance work on the side of a regular or temporary job (moonlighters or temporary workers). Between 2014 and 2015, the share of diversified workers in total employment increased from 6% to 9% in the United States, while other forms of independent work declined during this period in the United States (Mishel, 2015).

As workers in the "platform economy" are more likely to have multiple jobs and income sources, the role and meaning of traditional labour market institutions are being challenged. Statutory working hours, minimum wages, unemployment insurance, taxes and benefits are still modelled on the notion of a traditional and unique employer-employee relationship. In addition, as independent work becomes more common, an increasing number of workers may not be covered by collective agreements. They may also not be eligible for unemployment insurance and pension and health schemes available to employees and face difficulties in obtaining credit. Currently, in 19 out of 34 OECD countries, self-employed workers are not eligible for unemployment benefits and in 10 they are not eligible for work injury benefits. Even if eligible, the self-employed in many countries receive less generous benefits or enrolment is optional, as is commonly the case for insurance benefits, sickness/maternity, unemployment and old-age/disability/survivor benefits (OECD, 2015d).

Is there a risk of growing inequality?

The polarisation of the occupational structure into high-skilled and low-skilled jobs and between open-ended and various atypical forms of employment may entail further polarisation of the wage structure into high-paying and low-paying jobs. In some countries, the reduction in the demand for workers with middle-level skills has reinforced competition for lower-paid jobs which has held down wages in the bottom half of the earnings distribution. At the same time wages at the top of the distribution have risen because of the high demand for workers with high-level skills. These developments could increase the risk of experiencing in-work poverty and the persistence of low income from work (OECD, 2015d, 2015e).

The shift to capital-intensive modes of production could also spur further declines in the labour share of GDP and further increases in inequality. The changes in the occupational structure may create regional inequalities, as new jobs are created in cities with a high concentration of highly-skilled workers, which are usually different cities than those experiencing displacement or job losses (Berger and Frey, 2016).

In the face of these developments, labour market and skill policies as well as tax and benefit schemes will need to be adapted to promote skills adaptation as well as labour mobility while at the same time ensuring that work, even low-paying work, provides a sufficient income to escape poverty.

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A COMPARATIVE ANALYSIS

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Ulrich Zierahn

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THE RISK OF AUTOMATION FOR JOBS IN OECD COUNTRIES: A COMPARATIVE ANALYSIS.

OECD SOCIAL, EMPLOYMENT AND MIGRATION WORKING PAPERS No. 189

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SUMMARY

In recent years, there has been a revival of concerns that automation and digitalisation might after all result in a jobless future. The debate has been fuelled by studies for the US and Europe arguing that a substantial share of jobs is at "risk of computerisation". These studies follow an occupation-based approach proposed by Frey and Osborne (2013), i.e. they assume that whole occupations rather than single job-tasks are automated by technology. As we argue, this might lead to an overestimation of job automatibility, as occupations labelled as high-risk occupations often still contain a substantial share of tasks that are hard to automate.

Our paper serves two purposes. Firstly, we estimate the job automatibility of jobs for 21 OECD countries based on a task-based approach. In contrast to other studies, we take into account the heterogeneity of workers' tasks within occupations. Overall, we find that, on average across the 21 OECD countries, 9 % of jobs are automatable. The threat from technological advances thus seems much less pronounced compared to the occupation-based approach. We further find heterogeneities across OECD countries. For instance, while the share of automatable jobs is 6 % in Korea, the corresponding share is 12 % in Austria. Differences between countries may reflect general differences in workplace organisation, differences in previous investments into automation technologies as well as differences in the education of workers across countries.

The second purpose of this paper is to critically reflect on the recent line of studies that generate figures on the "risk of computerisation" and to provide a comprehensive discussion on possible adjustment processes of firms and workers to automation and digitalisation. In particular, we argue that the estimated share of "jobs at risk" must not be equated with actual or expected employment losses from technological advances for three reasons. First, the utilisation of new technologies is a slow process, due to economic, legal and societal hurdles, so that technological substitution often does not take place as expected. Second, even if new technologies are introduced, workers can adjust to changing technological endowments by switching tasks, thus preventing technological unemployment. Third, technological change also generates additional jobs through demand for new technologies and through higher competitiveness.

The main conclusion from our paper is that automation and digitalisation are unlikely to destroy large numbers of jobs. However, low qualified workers are likely to bear the brunt of the adjustment costs as the automatibility of their jobs is higher compared to highly qualified workers. Therefore, the likely challenge for the future lies in coping with rising inequality and ensuring sufficient (re-)training especially for low qualified workers.

RÉSUMÉ

Ces dernières années, les craintes que l'automatisation et la numérisation aboutissent finalement à un futur sans emploi se sont réveillées. Le débat a été alimenté par des études sur les États-Unis et l'Europe arguant qu'une grande partie des emplois étaient en « risque d'informatisation ». Ces études utilisent une méthode basée sur les professions proposée par Frey et Osborne (2013), c'est-à-dire qu'elles supposent que les professions dans leur ensemble et non les tâches isolées sont automatisées. Comme nous l'avançons, cette hypothèse peut mener à la surestimation de l'automatisation des emplois, puisque les professions dites à haut risque comprennent souvent une part substantielle de tâches difficiles à automatiser.

Notre article a un double objectif. D'une part, nous estimons par une approche basée sur les tâches la possibilité d'automatiser les emplois pour 21 pays de l'OCDE. A la différence d'autres études, nous prenons en compte l'hétérogénéité des tâches au sein des professions. Globalement, nous estimons que 9 % des emplois sont automatisables en moyenne dans les 21 pays de l'OCDE. La menace générée par les avancées technologiques semble donc bien moindre que celle donnée par la méthode basée sur les professions. Nous trouvons également que les pays de l'OCDE sont hétérogènes en la matière. Par exemple, alors que la part des emplois automatisables représente 6 % en Corée, elle s'élève à 12 % en Autriche. Les différences entre pays peuvent être le reflet des diversités concernant l'organisation du lieu de travail en général, des différences dans les investissements faits auparavant dans les technologies d'automatisation ou encore des variations dans les niveaux d'éducation des travailleurs.

Le second objectif de cet article est de procéder à une réflexion critique sur un groupe d'études récentes qui produisent des chiffres sur le « risque d'informatisation » et de fournir une discussion approfondie sur les processus possibles d'adaptation à l'automatisation et à la numérisation pour les entreprises comme pour les travailleurs. En particulier, nous avançons que l'estimation de la part des « emplois à risque » ne doit pas être assimilée aux pertes d'emplois effectives ou prévues liées aux avancées technologiques. D'une part, l'utilisation de nouvelles technologies est un processus long, ralenti par les obstacles économiques, légaux et sociaux, de telle sorte que souvent la substitution technologique ne s'effectue pas comme prévu. D'autre part, même si des changements technologiques sont introduits, les travailleurs peuvent s'y adapter en changeant leurs tâches, de manière à prévenir le chômage technologique. Enfin, le changement technologique génère aussi des emplois supplémentaires liés à la demande pour les nouvelles technologies et à l'accroissement de la compétitivité.

La conclusion principale de notre article est qu'il est peu probable que l'automatisation et la numérisation détruisent un grand nombre d'emplois. Cependant, les travailleurs peu qualifiés souffriront plus des coûts d'ajustement car leur emploi est davantage susceptible d'être automatisé que pour les travailleurs qualifiés. Ainsi, le défi futur consiste probablement à faire face à la croissance des inégalités et à veiller à former (ou former à nouveau) les travailleurs peu qualifiés.

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INTRODUCTION

1. In the past, technological change often stoked fears that new technological means displace workers, hence giving rise to what has been called technological unemployment (see Mokyr et al., 2015 for a comprehensive review of the literature). While such fears have not proven true for past technological advances in the 19th and 20th century as the creation of new jobs usually outran the labour-saving impact of the adoption of new technologies, fears have recently been growing again that technological advances in the field of automation and digitalisation may after all herald the “End of Work”, as has already been proposed by Rifkin (1995). The underlying notion is that automation and digitalisation are increasingly penetrating the domain of tasks that until recently used to be genuinely human such as reasoning, sensing and deciding. In a widely discussed book, Brynjolfsson and McAfee (2014) present numerous examples of what they call “The Second Machine Age” such as the driverless car, the largely autonomous smart factory, service robots or 3D printing. These technologies are driven by advances in computing power, robotics and artificial intelligence and ultimately redefine what type of human capabilities machines are able to do.

2. Hence, at least in the public debate, the prevalent perception seems to be that the substitutability of humans by machines reaches a new and unprecedented quality. Such fears have also been fuelled by a study conducted by Frey and Osborne (2013) that tries to estimate the susceptibility of employment to computerisation. In this widely cited paper, they classify occupations in the US with respect to the risk of being susceptible to automation by asking experts about the technological potential for automation in the near future. As a result, the study suggests that 47% of all persons employed in the US are working in jobs that could be performed by computers and algorithms within the next 10 to 20 years. Several follow-up studies applied the risk of automation at the level of occupations to other countries, thereby assuming that the risk of automation for a particular occupation is comparable across countries. Hence, cross-country differences in the estimated share of workers that are prone to automation are driven by differences in the occupational structure only. With this approach, Pajarinen and Rouvinen (2014) estimate the share of jobs that are susceptible to automation to be around 35% in Finland while Brzeski and Burk (2015) estimate the share of jobs at risk of automation to be as high as 59% in Germany. Bowles (2014) finds the share of jobs that are susceptible to automation in Europe to range between 45 to more than 60%, with southern European workforces facing the highest exposure to a potential automation.

3. Given these numbers, the potential for automation is perceived as a threat that will ultimately foster technological unemployment. However, the study by Frey and Osborne (2013) has also spurred a discussion about the interpretation of these results. In particular, one critique targets the fact that automation usually aims at automating certain tasks rather than whole occupations. Since occupations usually consist of performing a bundle of tasks not all of which may be easily automatable (Autor 2014, 2015), the potential for automating entire occupations and workplaces may be much lower than suggested by the approach followed by Frey and Osborne. Moreover, even within occupations, the heterogeneity of tasks performed at different workplaces appears to be huge as recently shown by Autor and Handel (2013). In fact, most of the adjustment to the past computerisation occurred through changing task structures within occupations, rather than changing employment shares between occupations (Spitz-Oener 2006).

4. A second critique aims at confounding the potential for automation with actual employment losses. In particular, the technical possibility to use machines rather than humans for the provision of certain tasks need not mean that the substitution of humans by machines actually takes place. In many

cases, there are legal as well as ethical obstacles that may prevent such a substitution or at least substantially slow down its pace. Moreover, the substitution may not be reasonable from an economic point of view. However, even in the absence of such obstacles, workers may adjust to a new division of labour between machines and humans by switching tasks.

5. The aim of this study is to estimate the risk of automation for jobs in 21 OECD countries[1] based on the approach by Frey and Osborne (2013), while relaxing one of their major assumptions as in our earlier study for Germany (Bonin et al. 2015). Rather than assuming that it is occupations that are displaced by machines, we argue that it is certain tasks that can be displaced. To the extent that bundles of tasks differ across countries and also within occupations, occupations at risk of being automated according to Frey and Osborne may well be less prone to automation when considering the fact that most occupations contain tasks that are difficult to substitute at least in the foreseeable future.

6. In this paper, we re-estimate the share of jobs at risk of automation for 21 OECD countries including the US using a task-based approach. For this purpose, we use the recently released PIACC database (Programme for the International Assessment of Adult Competencies) that surveys task structures across OECD countries. Overall, we find the share of jobs at risk of automation to be, on average across OECD countries, 9 %. However, these numbers may be limited in informing us about the potential impact of technological advances. In particular, the paper discusses several reasons why these numbers may still not be equated with actual expected employment losses from technological advances.

7. We find that applying a task-based approach results in a much lower risk of automation compared to the occupation-based approach. For instance, while Frey and Osborne find that 47 % of US jobs are automatable, our corresponding figure is only 9 %. The threat from technological advances is thus much less pronounced compared to the occupation-based approach by Frey and Osborne. This substantial difference is driven by the fact that even in occupations that Frey and Osborne considered to be in the high risk category, workers at least to some extent also perform tasks that are difficult to automate such as tasks involving face-to-face interaction.

8. As a final result, we find heterogeneities across OECD countries. For instance, while the share of automatable jobs is 6 % in Korea, the corresponding rate is 12 % in Austria. As we show, parts of the differences across countries may reflect general differences in workplace organisation, differences in previous investments into automation technologies as well as differences in the education of workers across countries.

1. We estimate the automatibility for all countries which are included in the currently available PIAAC data, excluding Russia.

THE THREAT OF AUTOMATION ACCORDING TO FREY AND OSBORNE

9. With their analysis of the susceptibility of jobs to computerisation, FO (from now on referring to Frey and Osborne 2013) started a controversial discussion about the potential threats from current and future technological advances. In the public debate, their result that 47% of all US jobs might be at risk of being automated in the near future clearly stoked fears that technological unemployment is likely to affect a large and increasing share of the population. Yet, in order to actually interpret these results correctly, it is important to better understand their empirical approach in the first place.

10. FO focus on the technological advances in what they call Machine Learning (ML) and Mobile Robotics (MR). Their starting point is the assumption that these advances differ from previous technological advances in that the technological capabilities to perform tasks that have until recently been considered genuinely human are increasing rapidly. In particular, these tasks are no longer confined to routine tasks as has been the assumption of most studies in labour economics in the past decade (see Acemoglu and Autor, 2011, and Autor, 2013, for reviews of the literature). Instead, machines are increasingly capable of performing non-routine cognitive tasks such as driving or legal writing. In particular, advances in the field of Machine Learning (ML, e.g. computational statistics and vision, data mining, artificial intelligence) allow for automating cognitive tasks, while the use of ML in Mobile Robotics (MR) also allows for automating certain manual tasks.

11. FO argue that due to these advances, creative destruction, i.e. technological unemployment as a result of workers seeking new jobs after being laid off, is likely to exceed what has been called the capitalization effect (Aghion and Howitt 1994). The latter effect refers to the growth-enhancing and ultimately job-creating effect of technological advances that in the past apparently outweighed the initial, labour-saving effect of technology. Since the current speed with which human labour becomes potentially obsolete is high and even increasing, attempts to upgrade skills and education may no longer suffice to win the “Race Against the Machines” as titled by Brynjolfsson and McAfee (2011). Hence, unprecedented levels of technological unemployment may arise. The only domain of tasks that according to FO appears to be exempt from this threat, is related to what they call Engineering Bottlenecks. Such bottlenecks refer to tasks that cannot be substituted by machines in the near future as these tasks cannot be defined in terms of codifiable rules and thus algorithms.

12. One of these bottlenecks refers to tasks that are related to perception and manipulation, especially when such tasks are performed in unstructured situations. The capability of workers in handling objects in such contexts is still a huge challenge for engineers. In particular, humans are likely to have long-lasting comparative advantages when it comes to orienting oneself in complex situations and to react to potential failures and unstructured challenges.

13. Other tasks that are likely to remain the domain of humans are related to creativity and social intelligence. According to FO, creativity is the ability to develop new and meaningful ideas or artefacts such as new concepts, theories, literature, or musical compositions. Although certain parts of these tasks might be automatable to some extent, FO consider true creativity that relates these new ideas to the cultural and contemporary context of changing societal perceptions as a domain that is likely to be dominated by humans in the foreseeable future. Similarly, tasks that necessitate social intelligence, i.e. the ability to intelligently and empathically respond to a human counterpart, remain a highly challenging domain from an engineering point of view. Tasks such as persuading, negotiating or caring for others are thus likely to remain genuinely human even in the long run.

14. Against this background, FO discuss the task model of Autor et al. (2003) that considers a constant return to scale aggregate production function with two types of labour inputs: Routine tasks that are technically substitutable by capital and non-routine tasks that are not substitutable. FO adapt this model by redefining the domain of tasks that are susceptible to automation and those that, due to the engineering bottlenecks, are not. Hence, tasks that could potentially be automated go beyond the routine tasks as defined in Autor et al. (2003), reflecting new advances in ML and MR.

15. An important difference between the task model as used by Autor et al. (2003) and FO is that the former discuss the substitution of routine tasks by machines as a result of profit maximising firms. Hence, whether substitution takes place hinges not only on technological capabilities, but on the relative price of performing tasks by either humans or machines. In contrast, FO only assess the technical capability of substituting a certain tasks by machines and not its economic feasibility.

16. In order to identify the capability of substituting occupations with machines, their empirical analysis is based on the 2010 version of the O*NET data. This database contains information about the task content of 903 occupations in the US and is based on the assessment of labour market analysts as well as experts and workers in a particular occupation. In order to merge wage and employment data to these occupations, FO aggregate the 903 O*NET occupations to 702 occupations of the Labour Department's Standard Occupational Classification (SOC) by taking the mean of the tasks as reported in the O*NET data whenever occupations had to be aggregated.

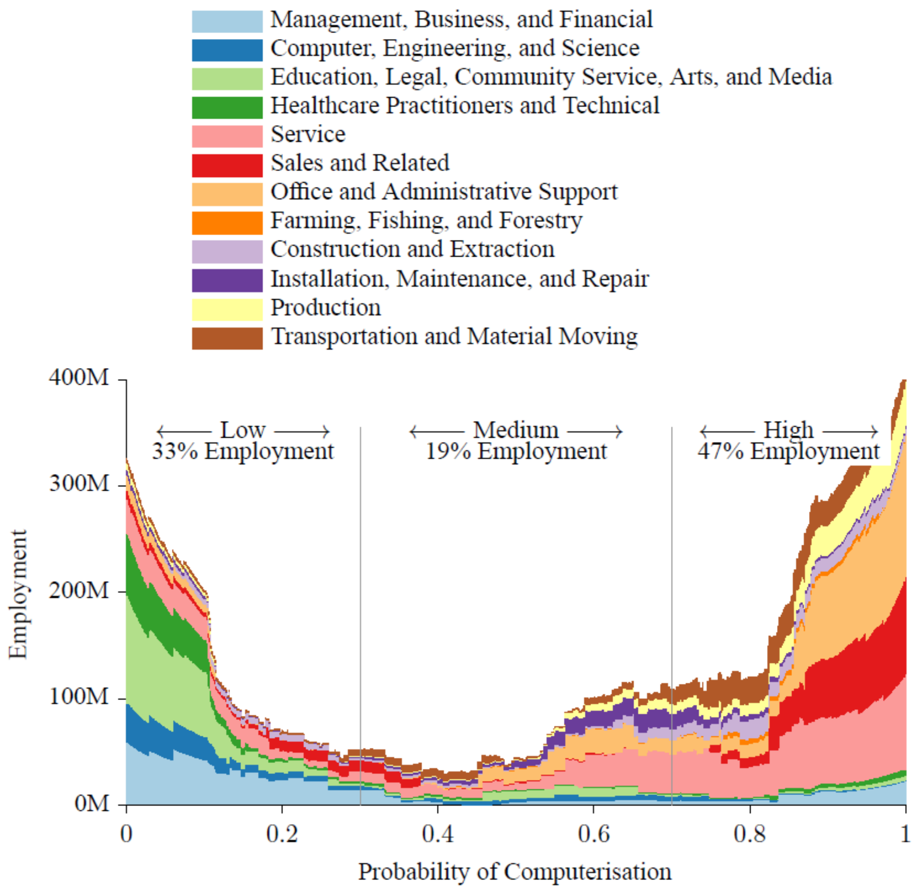
17. Afterwards, they ask ML researchers in the context of a workshop at Oxford University Engineering Sciences Department to classify occupations into being either automatable or not based on the reported task structures.[2] From this classification purpose, they select only 70 occupations whose labelling the experts were highly confident about. FO then impute the automatibility to the remaining 632 occupations by proceeding as follows. First, they examine whether this subjective classification is systematically related to nine objective attributes of the occupations that are related to the identified engineering bottlenecks (e.g. manual dexterity, originality, social perceptiveness). These bottleneck-tasks were defined only after the workshop and had not been part of the occupational task structures that formed the basis for the experts' assessment. FO then estimate various variants of a probabilistic model to examine the power of these bottleneck-related attributes in predicting an occupation's automatibility. They repeat this exercise with 100 randomly selected subsamples of the 70 classified occupations and find a high predictive power of these attributes for the subjective assessment of each occupation's automatibility.

18. The model estimates are used to predict the probability with which each of the 632 occupations that had not been assessed by the experts could potentially be automated. FO then distinguish between low risk (less than 30%), medium risk (30-70%) and high-risk (>70%) occupations. Combining this information with the number of employees in each occupation in the US, as reported for 2010 by the Bureau of Labor Statistics, FO infer that 47% of all jobs in the US are in the high risk category, *"meaning that associated occupations are potentially automatable over some unspecified number of years, maybe a decade or two"* (FO 2013, p. 38). According to this, it is especially service, sales and office jobs that fall in the high-risk category, see Figure 1. Beyond high-risk occupations, FO assume that automation will take place at a much lower pace as the engineering bottlenecks have to be resolved first. Moreover, they find that the risk of automation is higher for low-skilled workers and for low-wage occupations, suggesting that automation could disproportionately affect these groups of workers.

2. Experts were asked: „Can the tasks of this job be sufficiently specified conditional on the availability of big data, to be performed by state of the art computer-controlled equipment" (Frey and Osborne, 2013: 30)

19. Although FO repeatedly stress that they focus on technological capabilities only, their results of jobs being "at risk" of automation and the follow-up studies by other scholars (see next section) set off a heated debate about the potential threats from technological advances. Yet, there are many reasons why the automatiblity of jobs might not resolve in actual job losses. Besides several other reasons (see Section "Interpretation and Critique"), one main factor that FO leave aside is that it is usually not an occupation, but rather a certain task that can be automated or not, i.e. it is tasks rather than occupations that are at risk. In the next section, we therefore provide an alternative approach to estimate the risk of automation for 21 OECD countries based on the actual task content of jobs.

Figure 1. **US Employment by Risk Category (Frey/Osborne 2013, p.37)**



Source: Frey and Osborne (2013), The Future of Employment: How Susceptible are Jobs to Computerization? University of Oxford.

AUTOMATIBILITY OF JOBS IN OECD COUNTRIES – A TASK-BASED APPROACH

20. Below, we transfer the automatibility as provided by FO to other OECD countries. Some authors have done this by assuming that occupations in the studied countries are comparable to US occupations. In order to derive similar automation scenarios as in FO, they directly transferred the automatibility as reported by FO at the occupational level to occupation-specific employment data in Germany (Brzeski and Burk 2015), Finland (Pajarinen and Rouvinen 2014) or European Countries (Bowles 2014). We refer to this method as the occupation-based approach. A main drawback of the occupation-based approach is that it assumes occupations to be similar across countries. Moreover, direct correspondences between the occupational classifications of these countries and the Standard Occupational Classification (SOC) of the US typically do not exist. Finally, FO assume that occupations can be automated, assuming that workers within the same occupation have identical task structures. However, workers' task structures differ remarkably within occupations (Autor and Handel 2013). Hence, even within occupations, workers likely are very differently exposed to automation depending on the tasks they perform. Therefore, we follow an alternative task-based approach that copes with these issues. In short, we estimate the relevance of tasks for the automatibility of jobs in the US and use this empirical relationship to transfer the automatibility to other OECD countries. In the remainder of the chapter, we first present the data and methodology. Then, we present the results of the task-based approach for the US, before transferring the automatibility to other OECD countries.

A. Data and Methodology

21. In this paper, we follow a task-based approach to transfer the results by FO to other OECD countries. The approach is based on the idea that the automatibility of jobs ultimately depends on the tasks which workers perform for these jobs, and how easily these tasks can be automated. We therefore estimate the relationship between workplace tasks in the US and the automatibility by FO. We then use this statistical relationship to transfer the automatibility to jobs in other OECD countries. At first sight, this procedure has some similarities with the analysis of FO, who estimate how the experts' assessment of the automatibility at the occupational level is related to some bottleneck-tasks, to transfer these results to other occupations. However, while they use only a limited set of bottleneck-tasks that reflect average task structures at the occupational level, we rely on individual survey data regarding a comprehensive list of tasks that people actually perform at their workplace. Using individual-level data, we thus take into account that individuals within the same occupation often perform quite different tasks. Moreover, the task structures are self-reported by the individuals and thus likely a better indicator of workers' actual tasks.

22. The analysis is based on data from the Programme for the International Assessment of Adult Competencies (PIAAC). The PIAAC data is a unique data source which contains micro-level indicators on socio-economic characteristics, skills, job-related information, job-tasks and competencies. Most importantly, the data is comparable across the countries in the program. Hence, the data also allows for relaxing the assumption that task structures are the same across countries.

23. To implement our task-based approach, we estimate the relationship between workers' tasks and the automatibility of jobs in the US. For this we match the automatibility indicator by FO to the US observations in the PIAAC data based on the occupational codes. As only 2-digit ISCO codes are available in the PIAAC, an assignment problem arises. We therefore assign multiple values of the automatibility to

each individual in the PIAAC data and follow a multiple imputation approach. For each individual in the PIACC data, we identify the automatibility with the highest probability based on this method. In particular, we follow Ibrahim (1990) and implement the following Expectation-Maximization (EM) algorithm:

(1) In a first step, we regress the automatibility *y* on the *N* characteristics *x* of the jobs:

$$y_{ij} = \sum_{n=1}^{N} \beta_n x_{in} + \epsilon_{ij}$$

where i are the individuals in the PIAAC-data and j are the duplicates of these individuals, since multiple automatibilities y_{ij} are assigned to each individual i. β_n are the parameters to be estimated, which represent the influence of the job-related characteristics on the automatibility of each job. The automatibility is restricted to the interval 0% to 100%. We use the Generalized Linear Model (GLM) by Papke and Wooldridge (1996) where the dependent variable of the model is transferred to a non-restricted interval. In addition, we take into account two weights which we connect multiplicatively. The first weight is necessary, because we have duplicated the individuals in the dataset. This weight is therefore constructed such that it sums to unity for each individual. For the initial step of the algorithm, we set this weight to the inverse number of duplicates of each individual. The second weight is the replication weight of the PIAAC data.

(2) In a second step, we predict the automatibility $\hat{y_i}$. Note that these values do not vary within individuals, as the job-related characteristics x_{in} are constant within individuals. By comparing the automatibilities y_{ij} and the predicted automatibility $\hat{y_i}$ we can determine the likelihood that y_{ij}, given the job-related characteristics x_{in} and the estimated model, is the true automatibility. Based on this likelihood, we recalculate the first weight and continue with step 1 (see Ibrahim 1990).[3] We run this algorithm until the weights converge.

24. We implement this model for employed individuals based on US observations in the PIAAC data, excluding armed forces and individuals with missing occupational information or individuals whose occupation is available only at the 1-digit ISCO level. Our explanatory variables mostly cover indicators of workplace tasks, but we further consider gender, education, competences, income, sector, firm-size and further auxiliary variables. The explanatory variables and their descriptive statistics are outlined in Table 2 in Annex A. Variable definitions can also be found in Annex A. The model and estimated parameters then show the influence of the explanatory variables on the automatibility in the US. We then apply this model and the estimated parameters to the PIAAC data in other OECD countries to predict the automatibility for these countries.

25. Through this procedure, we take into account that not whole occupations, but specific jobs are exposed to automatibility, depending on the tasks performed at these particular jobs. The procedure is based on the idea that jobs with larger shares of automatable tasks are more exposed to automatibility than jobs with larger shares of non-automatable tasks (bottlenecks, using the wording of FO). The procedure allows for differences in task-structures within occupations and specifically focuses on the individual job. This approach is less restrictive than the occupation-based approach, which relies on the assumption that occupational task structures are identical in the US and other countries. However, with this procedure we

3. More precisely, the first weights w_{ij} are calculated as $w_{ij} = \frac{f(\hat{y_i} - y_{ij} | x_{in}, \beta_n)}{\sum_{j=1}^{J} f(\hat{y_i} - y_{ij} | x_{in}, \beta_n)}$ where f(.) is the standard normal density. This is based on equation 3.4 in Ibrahim (1990) and follows from Bayes theorem. Note that Ibrahim (1990) presents the EM algorithm for the case of missing explanatory variables, but the procedure can also be applied to missing dependent variables, as in our case.

assume that workers with the same task structure face the same automatibility in all OECD countries. Any differences of automatibilities between the countries then originate from differences in task structures or other explanatory variables between the countries.

B. Results for the US

26. We present the main results for the US below, the detailed results of our model can be found in Annex B. Overall, we find that the automatibility of jobs is lower in jobs with high educational job requirements or jobs which require cooperation with other employees or where people spend more time on influencing others. Hence, the low-risk tasks partially reflect what FO called engineering bottlenecks. The automatibility is higher in jobs with a high share of tasks that are related to exchanging information, selling or using fingers and hands. This resembles the evidence from the task-based literature which argues that so-called routine tasks are subject to automation, whereas interactive or cognitive tasks are less likely to be substituted by machines and computers (see Acemoglu and Autor (2011) or Autor (2013) for an overview of the literature).

27. Figure 2 compares the predicted automatibility of jobs in the US using the PIAAC data when applying the task- and the occupation-based approach. For the occupation-based approach, we matched all potential FO-values to each individual in the US-PIAAC-data based on the 2-digit ISCO occupation.[4] The result strongly resembles the bi-polar structure which is known from FO and shown in Figure 1 – the majority of jobs is assigned either a very high or a very low automatibility, only few jobs have a medium automatibility. In contrast, the result from the task-based approach show a very different pattern – the two poles of the distribution move to less extreme values of the automatibility. Hence, fewer jobs have either very high or very low values of automatibility when taking into account the variation of task-structures within occupations. As a result, only 9% of all individuals in the US face a high automatibility, i.e. an automatibility of at least 70%. This figure stands in contrast to FO, who argue that 47% of US jobs are at high risk of being automated. Apparently, not taking account of the variation of tasks within occupations exerts a huge impact on the estimated automatibility of jobs. This is because even in occupations that FO expect to be at a high risk of automation, people often perform tasks which are hard to automate, such as for example interactive tasks (e.g. group work or face-to-face interactions with customers, clients, etc.). This can be illustrated by two examples:

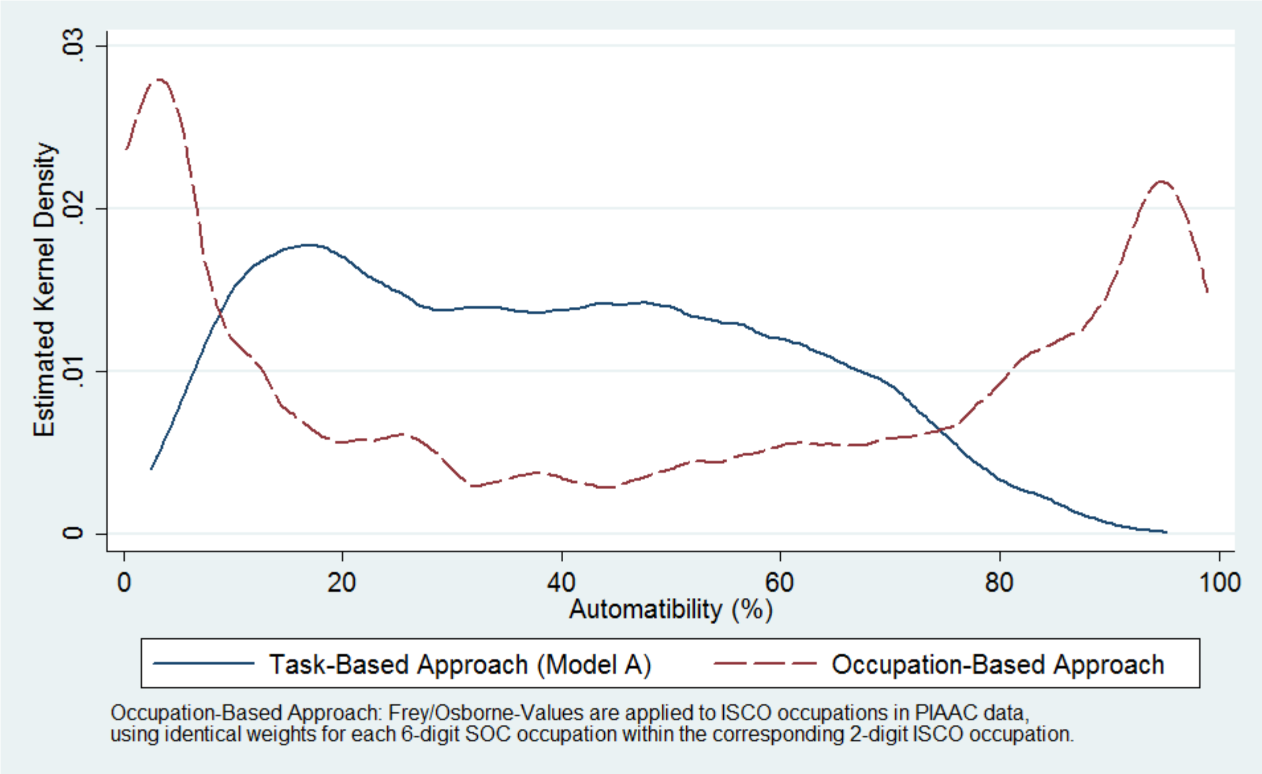
- According to FO, people working in the occupation “Bookkeeping, Accounting, and Auditing Clerks” (SOC code: 43-3031) face an automation potential of 98%. However, only 24% of all employees in this occupation can perform their job with neither group work nor face-to-face interactions.

- According to FO, people working in the occupation “Retail Salesperson” (SOC code 41-2031) face an automation potential of 92%. Despite this, only 4% of retail salespersons perform their jobs with neither both group work nor face-to-face interactions. [5]

4. For the occupation-based approach, we matched all potential FO-values to each individual in the US-PIAAC-data based on the 2-digit ISCO occupation. Each individual is assigned multiple FO-values due to the assignment problem. We equally weight each observation within each individual.

5. These results are based on the Princeton Data Improvement Initiative (PDII). We rely on this data rather than the PIAAC, because in the PDII 6-digit SOC codes are available, which allows us to circumvent the assignment problem.

Figure 2. **Distribution of Automatibility in the US (Task-Based vs. Occupation-Based Approach)**



Source: Authors' calculation based on the Survey of Adult Skills (PIAAC) (2012)

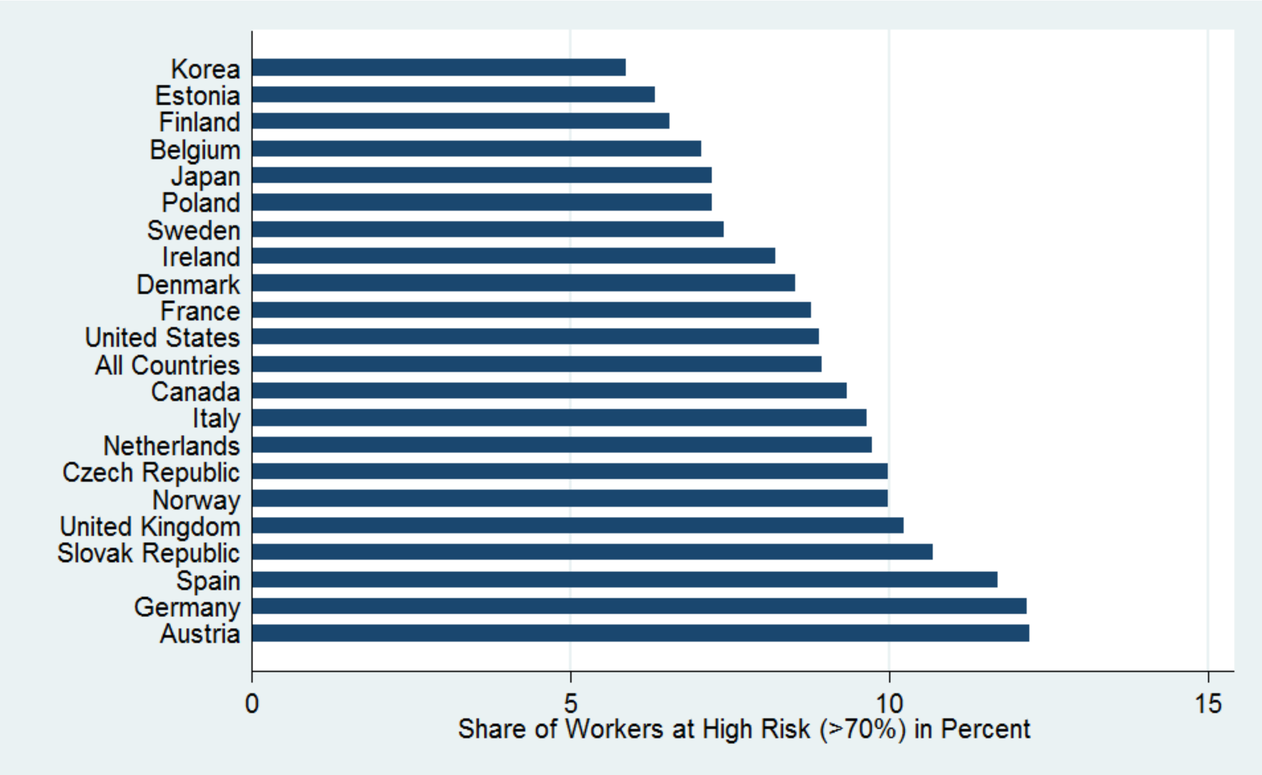
28. In conclusion, using information on task-usage at the individual level leads to significantly lower estimates of jobs "at risk", since workers in occupations with – according to FO – high automatibilities nevertheless often perform tasks which are hard to automate.

C. Results for other OECD countries

29. Figure **3** 3 shows the share of workers at high risk by OECD countries, i.e. the share of workers whose automatibility is at least 70%. This share is highest in Germany and Austria (12%), while it is lowest in Korea and Estonia (6%).[6] The results for Germany are very similar to the results of a recent representative survey among German employees, where 13 % of employees consider it likely or highly likely that their job will be replaced by machines (BMAS 2016). Furthermore, our results for Germany are comparable to a recent study by Dengler and Matthes (2015), who use a different methodological approach but also find that 15% of all jobs in Germany are at risk of automation. Moreover, they also find a bi-polar distribution of automatibility with moderate polarisation.

6. We exclude the Russian Federation from our sample. This is because when we restrict the Russian PIAAC sample to those observations where all relevant variables are non-missing, then the distribution of these variables is not representative. The results for Canada should be treated with some caution, as relevant explanatory variables for extrapolating the automatibility are missing, see Annex B.

Figure 3. **Share of Workers with High Automatibility by OECD Countries**



Source: Authors' calculation based on the Survey of Adult Skills (PIAAC) (2012)

30. An interesting result from Figure 3 is that the distribution of automatibility across countries does not lend itself to an immediate interpretation of potential underlying factors. To gain deeper insights into the underlying reasons for these country differences, we decompose the difference of the share of workers at high risk between each country and the US into a within- and between-industry component regarding three dimensions: industry, occupation, and education.[7] In each case, the between-component reflects the difference in automatibility that is due to the cross-country difference in industry, occupation or educational structure, while the within-component reflects the difference in automatibility that is due to the fact that workers in the same industries, occupations, or education group perform more (or fewer) automatable tasks.

31. The results in Table 1 show that differences in industry and occupational structures explain only little of the differences in the share of workers at high risk between each country and the US, as the between-industry and -occupation components matter only little for most countries. Instead, workers in the same industries and occupations perform differently automatable tasks in these countries than workers in the US. However, education plays a large role for many countries. In most countries, the within-education component is negative, which implies that people with the same education typically perform less

7. To compute the between-industry component, we first assign weights to each individual. These weights are the same for all individuals of the same industry. We choose the weights such that the share of workers by industry of each country resembles the US industry structure. We then recalculate the share of workers at high risk and calculate the difference of this figure to the original share of workers at high risk in each country. This difference resembles the between-component. The remaining difference of the country to the US-figures then resembles the within-component.

automatable tasks compared to the US. However, in many countries the between-education component is positive, which implies that in those countries a larger share of workers has educational levels which are associated with more automatable tasks (i.e. low or medium qualified workers). This is because the US has a larger share of highly educated workers, who typically perform fewer automatable tasks. These results also hold when focusing on educational requirements of the jobs rather than actual education.[8]

Table 1. **Decomposition of Country Differences in the Share of Workers at High Risk**

Country	Difference to the US	Industries		Occupations		Education	
		within	between	within	between	within	between
Austria	3.2%	2.7%	0.6%	3.3%	-0.1%	-2.2%	5.5%
Belgium	-1.9%	-1.6%	-0.3%	-1.1%	-0.7%	-3.1%	1.2%
Canada	0.4%	0.3%	0.0%	1.3%	-0.9%	-0.8%	1.2%
Czech Republic	1.0%	-0.2%	1.3%	-0.8%	1.8%	-2.0%	3.0%
Denmark	-0.4%	0.1%	-0.5%	-0.2%	-0.2%	-3.3%	2.9%
Estonia	-2.6%	-3.0%	0.4%	-1.4%	-1.2%	-2.9%	0.3%
Finland	-2.4%	-2.9%	0.6%	-3.3%	0.9%	-2.8%	0.4%
France	-0.2%	-0.3%	0.1%	-0.3%	0.1%	-1.5%	1.4%
Germany	3.2%	3.6%	-0.4%	2.0%	1.2%	0.1%	3.1%
Ireland	-0.7%	-0.6%	-0.1%	-0.5%	-0.2%	0.0%	-0.7%
Italy	0.7%	0.2%	0.5%	0.7%	0.0%	-3.7%	4.4%
Japan	-1.7%	-1.7%	-0.1%	-2.5%	0.8%	-0.8%	-0.9%
Korea	-3.1%	-2.8%	-0.3%	-3.6%	0.6%	-1.7%	-1.4%
Netherlands	0.8%	0.9%	-0.1%	1.2%	-0.4%	-4.9%	5.7%
Norway	1.0%	1.6%	-0.6%	1.4%	-0.4%	-3.4%	4.4%
Poland	-1.7%	-3.3%	1.6%	-2.7%	1.0%	-1.8%	0.1%
Slovak Republic	1.7%	1.2%	0.6%	2.0%	-0.2%	-0.2%	2.0%
Spain	2.8%	2.5%	0.3%	2.3%	0.5%	-1.4%	4.1%
Sweden	-1.5%	-1.0%	-0.5%	-1.5%	0.0%	-4.1%	2.6%
United Kingdom	1.3%	2.1%	-0.8%	0.1%	1.2%	-1.3%	2.6%

Source: Authors' calculation based on the Survey of Adult Skills (PIAAC) (2012)

32. As an example, in Austria, workers perform typically fewer automatable tasks compared to US-workers with the same educational level, but Austria has a higher share of low- and medium-skilled workers which perform more automatable tasks. Since the latter effect dominates, Austria has on aggregate a larger share of workers at high risk. In Korea, in contrast, both effects are negative, which implies that Koreans both perform fewer automatable tasks at each educational level compared to the US, and a larger share of Korean workers achieved educational levels which are associated with fewer automatable tasks compared to the US.

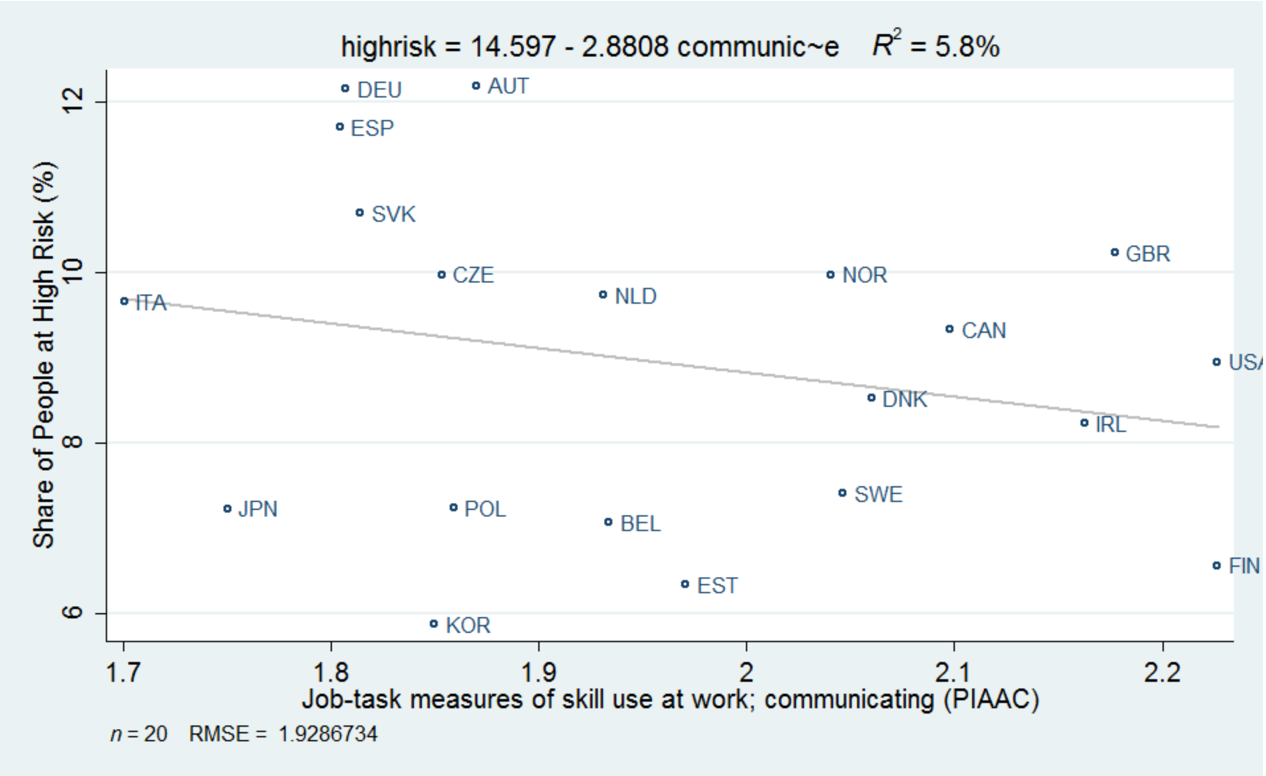
33. Hence, we can conclude that cross-country differences often reflect that individuals in the same industry, occupation or even education group perform different tasks. But what might be the reason behind such differences? In the following, we aim to briefly discuss two potential explanations: (1) general differences in the workplace organisation, and (2) differences in the adoption of new technologies.

34. In order to illustrate the first reason, consider, for example, two countries A and B which have adopted comparable technologies. The automatibility might nevertheless be higher in country A than in country B, because workplace organisation in country A generally relies less on group work or face-to-face interactions than country B. This is illustrated in Figure 4, which shows the relationship between the share

8. Results are available upon request.

of people at high risk and the incidence of communication tasks at the country level. On average, countries which have a stronger focus on communicative tasks in their workplace organisation also have a lower share of jobs at high risk. For instance, jobs in Italy and Germany show low degrees of communication, whereas jobs in the US and UK are more communicative. Overall, the analysis shows that genuine differences in workplace organisation are relevant for differences in automatibilities between countries.

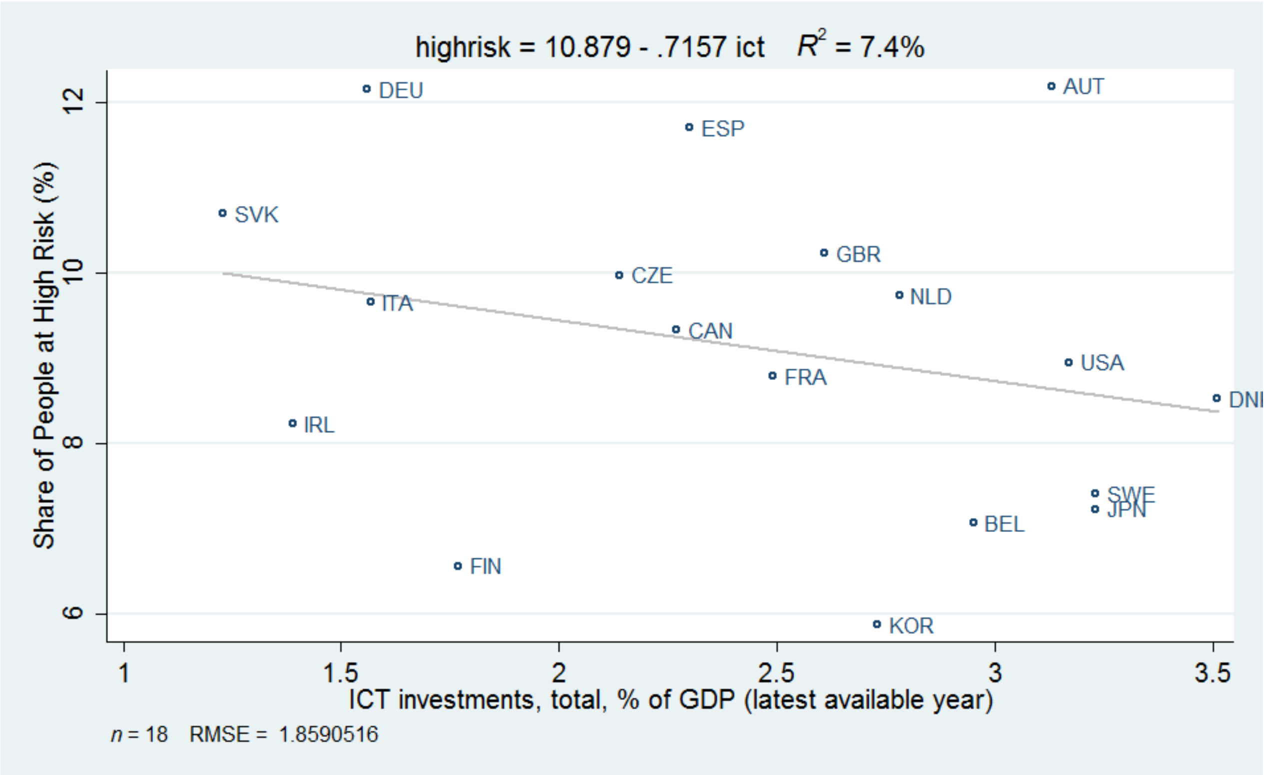
Figure 4. **Automatibility and Communicating**



Source: Authors' calculation based on the Survey of Adult Skills (PIAAC) (2012)

35. To illustrate the second reason, assume that there are no genuine differences in the workplace organisation of countries A and B. The automatibility of country A might still be higher than in country B, because country B invests stronger in new automation technologies and has hence already replaced labour by capital for performing the automatable tasks. Indeed, the automatibility is lower in countries which already invest a lot in ICT (see Figure 5). Hence, a high automatibility may reflect an unused potential for automation. Whether an extended use of automation technologies comes with beneficial or adverse effects on workers is unclear ex ante.

Figure 5. **ICT Investments and Automatibility**



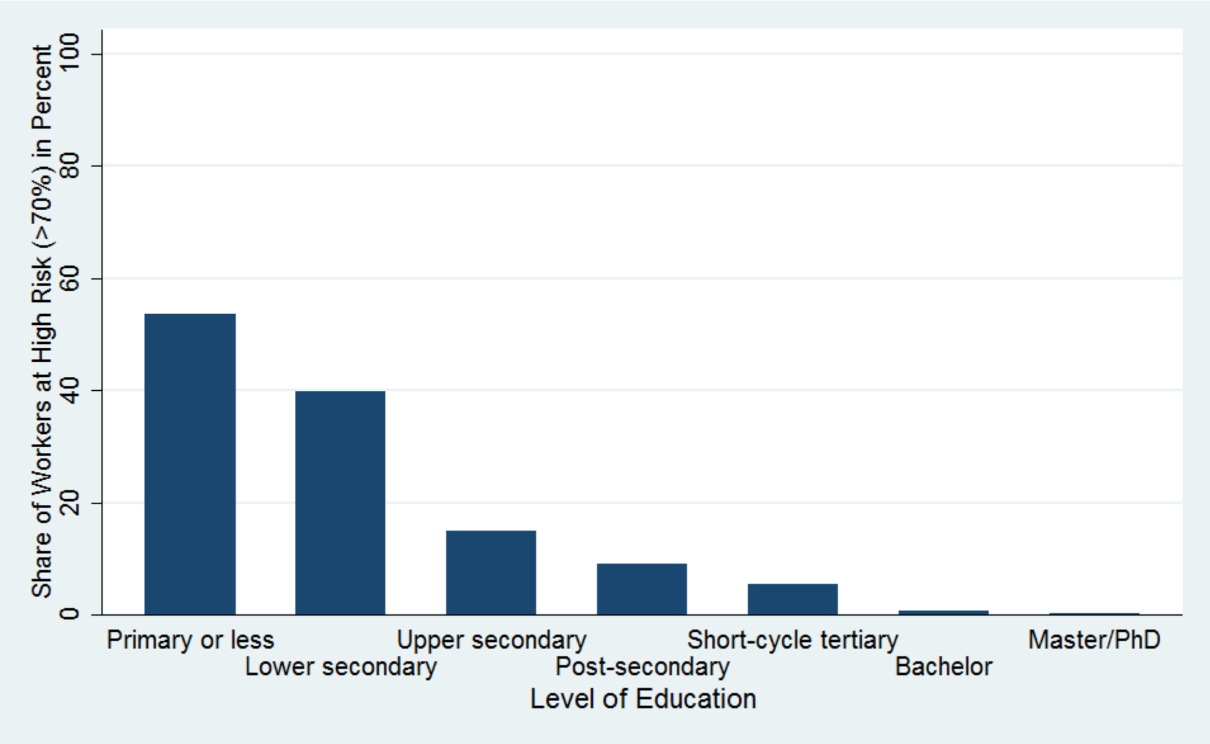
Source: Authors' calculation based on the Survey of Adult Skills (PIAAC) (2012)

36. Overall, we can conclude that comparing the automatibilities between countries is not straightforward and necessitates further insights into a country's adoption of new technologies, its economic and educational structure, its workplace organisation and the resulting task structures. Education and in particular the educational structure of the workers seem to play a large role. Countries with a strong focus on high qualified workers typically have lower shares of workers at high risk, since these workers typically perform fewer automatable tasks than low qualified workers. We therefore focus on the relationship between education and automatibility, below.

37. Despite the cross-country differences, a main feature of all countries is that the automatibility strongly decreases in the level of education and in the income of the workers: It is mostly low skilled and low-income individuals who face a high risk of being automatable. This is shown in Figure 6 and Figure 7 for a weighted average[9] of all OECD countries. Results for the individual countries can be found in Annex C.

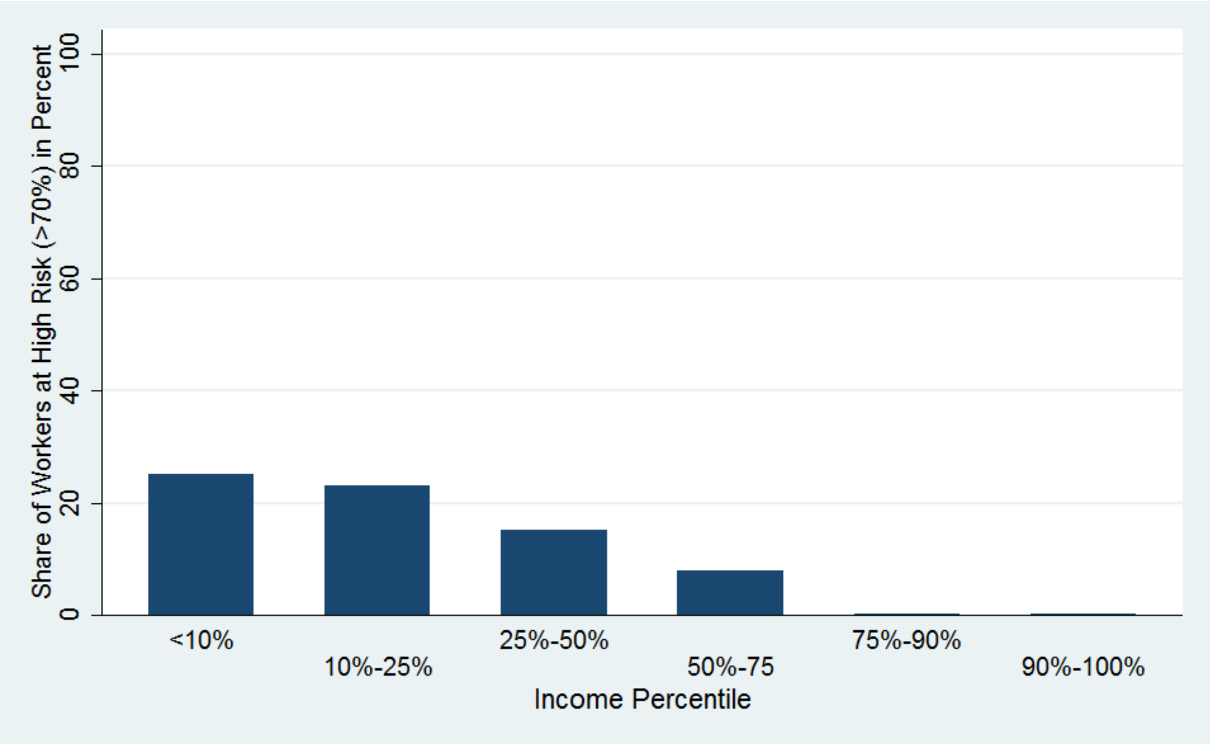
9. The figures are based on weighted data, so that large countries have a larger influence on the results. Nevertheless, the results are very similar when using unweighted data.

Figure 6. **Share of Workers with High Automatibility by Education**



Source: Authors' calculation based on the Survey of Adult Skills (PIAAC) (2012)

Figure 7. **Share of Workers with High Automatibility by Income**



Source: Authors' calculation based on the Survey of Adult Skills (PIAAC) (2012)

INTERPRETATION AND CRITIQUE

38. As discussed, FO predict that technologies allow for automating a substantial share of jobs within the next two decades. In addition, they assume that this process continues beyond the most-prone jobs in the medium run and ultimately affects even those that today appear to be relatively safe from automation. As discussed in the last chapter, applying a task-based approach that takes account of the heterogeneity of workplace tasks within occupations already strongly reduces the predicted share of jobs that are at a high risk of automation. This deviating result clearly sounds a note of caution regarding the interpretation of such predictions. Apparently, the mere fact that FO chose an occupation-based approach that abstracts from within-occupation variation in the tasks performed and that transfers the expert assessments for 70 occupations to the remaining occupations based on only three engineering bottlenecks and nine related tasks, has a strong effect on the outcome.

39. However, even for the less restrictive task-based approach, there are good reasons to be cautious when interpreting the results. Firstly, the approach still reflects technological capabilities based on experts' assessments rather than the actual utilisation of such technologies, which might lead an overestimation of job automatibility. Secondly, even when new technologies are increasingly used, the effect this has on employment prospects depends on whether workplaces adjust to a new division of labour or not. Workers might adjust by increasingly performing tasks that are complemented by the new technologies. Thirdly, the approach considers only existing jobs. Yet, the use of these technologies is likely to create new jobs. Moreover, new technologies may also exert positive effects on labour demand if they raise product demand due to an improved competitiveness and a positive effect on worker's incomes. Hence, workplaces are likely to be less "at risk" than suspected at first sight. In the following, we discuss these three aspects in more detail.

A. Overestimation of technological capabilities and its lagging utilisation

40. The experts assessing the automatibility of the 70 occupations in the FO study were asked whether *"[…] the tasks of this job [can] be sufficiently specified conditional on the availability of big data, to be performed by state of the art computer-controlled equipment"* (Frey and Osborne, 2013: 30). It is very likely that the resulting assessment overstates technological possibilities. First of all, experts tend to overestimate the potential of new technologies (Autor 2014, 2015, Pfeiffer and Suphan 2015). In particular, the comparative advantage of machines as compared to workers is typically overstated for tasks involving flexibility, power of judgement and common sense. More generally, the classification of occupations or tasks into the distinct domains automatable and not-automatable is problematic (Green 2012, Rohrbach-Schmidt and Tiemann 2013, Pfeiffer and Suphan 2015).[10] In addition, most jobs are probably not sufficiently well defined to be actually substituted by machines. As Pratt (2015) states for the advances in robotics "*specialized robots will improve at performing well-defined tasks, but in the real world, there are far more problems yet to be solved than ways presently known to solve them*" (Pratt 2015:52).

10. Green (2012, p. 41) finds that the classification of tasks into the distinct domains "routine" (i.e. automatable) and "non-routine" (i.e. non-automatable) using UK data. Also Rohrbach-Schmidt and Tiemann (2013) find that the results on the effects of technological change in Germany are sensitive to the subjective classification of tasks into either routine or non-routine. Pfeiffer and Suphan (2015, p. 11) criticises that "*the reasons why specific tasks are characterized as routine or non-routine […] are not clear. The decision process introduces a potential for circular reasoning because assignment follows an assumption already made about the likelihood of automation.*"

41. Moreover, the necessary condition for the utilisation of these technologies in terms of data and computer availability may not be met, at least not immediately. In fact, a monitoring report on the digitalisation of the German economy for the Federal Ministry of Economic Affairs recently revealed that the digitalisation of the manufacturing sector is still rather low and will advance only slowly until 2020 (Graumann et al. 2015). For example, a recent survey among German firms by the ZEW (2015) shows that only 18% of all firms are familiar with the concept “Industrie 4.0”, which is a project put forward by the German government to foster the digitalisation and interconnectedness of the German industry. Up to now, only 4% of firms have started or are about to start such projects. Hence, the utilisation of technologies clearly lags behind the technological possibilities. This may also be related to a shortage of qualified personnel that is able to handle these new technologies, as the introduction of new technologies may require the supply of complementary skills on the labour market (Acemoglu 1998). For example, Janssen and Mohrenweiser (2014) investigate the introduction of the new computer-based control system (Computerized Numerical Control, CNC) in the field of cutting machine operation into the German apprenticeship regulation. They find that this regulatory change in the apprenticeship regulation negatively affected workers who graduated before this regulatory change, and hence did not learn the use of the technology in their formal training. However, only workers who switched their occupation after the change were negatively affected, suggesting that the remaining workers learned the technology on the job. This indicates that the technology was only implemented by firms on a large scale after the application of the CNC technology had been introduced to the curricular of the apprenticeship training program.

42. Furthermore, even if sufficiently qualified personnel were available, firms decide on investing in new technologies depending on the relative factor prices of capital and labour in performing a certain task in the production process. Although the literature on routine-biased technological change showed that the reduction in prices for computer capital reduced the demand for routine-intensive jobs, it is not clear when the break-even point for machines to perform more complex tasks will actually be reached. This will, of course, also depend on the wage level which itself is endogenous and would thus react to an excess labour supply by lowering wages, hence improving worker’s employment prospects again. For this reason, technological capabilities need not translate into technological obsolescence of human labour (cf. Acemoglu and Restrepo 2015). The empirical approach of FO clearly leaves aside many factors that ultimately determine the decision to automate tasks and substitute human labour and that would prevent all technological capabilities from being exhausted. Hence, FO explicitly state that their empirical approach focusses on technological capabilities. The susceptibility of jobs to automation that they aim at identifying hence refers to such capabilities only.

43. Apart from company-related reasons for a rather low speed of technological adoption, there may also be ethical or legal obstacles to the utilisation of new technologies. As a prominent example that has recently been discussed by Thierer and Hagemann (2015) and Bonnefon et al. (2015), the autonomous car bears new legal challenges regarding e.g. liabilities in case of an accident. Moreover, there are unresolved ethical questions concerning how an algorithm should decide between crashing into a car or a truck. While some of these obstacles may be resolved at some point, they clearly slow down the pace with which technologies are spread. This can be illustrated using the example of driverless cars, which are often said to have a high disruptive potential. According to the Boston Consulting Group (2015), the share of driverless vehicles will reach 10% by the year 2035 which suggests a rather slow speed of change.

44. Finally, another aspect that should be considered is a strong societal preference for the provision of certain tasks and services by humans as opposed to machines. As an example, nursing or caring for the elderly may remain labour-intensive sectors, even if service robots increasingly complement these professions in the future. Hence, *“some human services will probably continue to command a premium compared to robotically produced one”* (Pratt 2015, p. 58), meaning that there is a societal value attached to humans performing certain tasks that tends to preserve their comparative advantage.

45. For all these reasons, the technological capabilities as assessed by FO are likely overestimated and should not be equated with the actual utilisation of technological advances.

B. Adjustment of workplace tasks

46. Even if a technology actually enters the production process, the impact on employment depends on whether workplaces are able to adjust to new demands. In particular, the new technologies may substitute for certain tasks and complement others. Hence, whether a workplace will be automated or not clearly depends on whether the tasks performed at a certain workplace shift from the first to the latter set of tasks. In fact, several studies suggest that although there has been a decline in jobs with predominantly routine and automatable tasks, the adjustment mainly takes place by changing the set of tasks within occupations (e.g. Autor at al. 2003, Spitz-Oener 2006). Workers seem to shift worktime from routine and automatable tasks to tasks that are complementary to machines.

47. The adoption of new technologies seems to come along with a new division of labour where workers increasingly perform tasks that complement machines (Autor 2013) of new and more complex tasks (Acemoglu and Restrepo 2015). As an example, tasks involving the monitoring of machines are likely to gain in importance. Hence, new technologies are unlikely to fully automate workplaces or occupations on a large scale, but rather change workplaces and the tasks involved in certain occupations. As long as workers are able to adjust to these new task demands, machines need not crowd out workers. However, as the findings from FO as well as the predictions in chapter 3 suggest, low-qualified workers perform a much higher share of potentially automatable tasks than high-qualified workers. If the tasks that complement machines become increasingly complex and demanding, the employment prospects for workers lacking certain skills may deteriorate.

C. Macroeconomic adjustment and indirect effects

48. The risk of automation as predicted by FO refers to the (likely overestimated) threat regarding the labour-saving impact of new technologies. This “risk of automation”, however, must not be equated with employment losses since there are macroeconomic feedback mechanisms that may also result in an increase in labour demand. Arntz et al. (2014) review the literature regarding these macroeconomic adjustment mechanisms. In particular, there are three mechanisms that counteract the labour-saving impact of technological advances.

49. First of all, labour-saving technologies need to be produced in the first place, thereby creating a demand for labour in new sectors and occupations. According to the OECD Digital Economy Outlook (OECD 2015) the ICT sector is a key driver of economic growth in OCED countries. Between 15 and 52% of all investments in OECD countries were related to the ICT sector between 2008 and 2013. Moreover, after a slack in the sector’s contribution to employment growth during the economic crises, the share of jobs created by the ICT sector in OECD countries amounts to 22% in 2013. FO do not take into account such positive demand effects. Moreover, due to focusing on the perceived risk for currently existing jobs only, FO neglect the fact that jobs of the future are likely to be complementary to the new technologies.

50. Secondly, new technologies may boost a firm’s competitiveness since new technologies typically increase a firm’s productivity. With lower costs and prices, firms face a higher product demand and hence demand more labour, which can (partially) compensate for the labour-saving effect of technologies. Graetz and Michaels (2015), for example, examine the effect of the utilisation of industrial robots in 17 countries and find no negative impact on the total working hours at the sector level. Hence, the use of new labour-saving technologies did not reduce the demand for labour. Similarly, Goos et al. (2014) develop a model of labour demand at the industry level for 16 European countries and find that routine-intensive industries that are at a higher risk of introducing labour-saving technologies gain

in competitiveness and face an increasing product demand. Similarly, Gregory et al. (2015) estimate a labour demand model at the level of European NUTS2 regions and show that regions with an initially high share of routine and highly automatable tasks actually gained in competitiveness, with the indirect positive effect on the regional product demand more than compensating the labour-saving substitution effect. In total, they find that the computerisation in fact generated 11.6 Million jobs on net across 27 European countries between 1999 and 2010.

51. Thirdly, to the extent that the new technologies complement workers, labour productivity increases. This may lead to either higher wages, or higher employment, or both, which in turn raises labour income. As a consequence, these workers may demand more products and services, thereby again increasing the demand for labour in the economy. In their labour demand model, Gregory et al. (2015) take these adjustment processes into account and find that they played a strong role for the positive net effect of technological change on employment in Europe. For past waves of technological innovations, several studies suggest that workers at least in the long run benefited from technological advances in terms of higher wages and income, although there is also evidence that there was at least a temporary increase in income inequality related to some technological innovations (see Mokyr et al 2015 for a review). For the recent past, Graetz and Michaels (2015) also find that the use of industrial robots at the sector level increased both labour productivity and wages for workers. Hence, to the extent that workers benefit from technological change in terms of higher wage income, technological progress can additionally boost labour demand via an increase in product demand.

52. Altogether, these macroeconomic mechanisms may compensate for the negative labour-saving effects of new technologies, so that large job-losses remain unlikely. On the contrary, total employment might even increase as argued above. Moreover, a recent study by Wolter et al. (2015) simulates the potential effects of the future digitalisation on the German economy (labelled as “Industry 4.0”). Even though they find only small negative effects on overall employment, their results suggests large shifts in employment between industries and occupations. In another paper, Nordhaus (2015) develops a theory of how new technologies can fully substitute for labour and analyses the conditions that need to be fulfilled for labour to become obsolete. He compares these to recent indicators for the US economy and this test suggests that the obsolescence of labour is unlikely to become relevant during this century. Hence, while the overall employment effects of future automation are presumably small, the development of digitised economies is likely associated with large shifts between occupations and industries, forcing workers to adjust to the changing economic environment.

CONCLUSIONS

53. In recent years, a series of studies have revived concerns that technological change might cause widespread technological unemployment. Especially Frey and Osborne triggered a public debate by claiming that 47% of US jobs are at risk of being automated. The present paper contributes to this debate by reflecting on some of the methodological problems of these studies. In particular, we argue that one of their major limitations is that they view occupations rather than tasks as being threatened by automation. We therefore focus on the task-content of jobs, as workers within the same occupation often perform different tasks. As we argue throughout this article, many workers in occupations that have been classified as vulnerable to automation in these studies may in fact be less exposed to automation than previously thought. The reason is that workers often perform a substantial share of non-routine interactive tasks, which are known to be less automatable.

54. In this paper, we therefore estimate the automatibility for 21 OECD countries following a task-based rather than an occupation-based approach. For this, we use data on actual workplace tasks as recently surveyed in the PIACC database for OECD countries. Overall, our figures suggest that 9 % of OECD jobs are potentially automatable. Moreover, we find that in the US only 9% of jobs rather than 47%, as proposed by Frey and Osborne face a high automatibility. The threat from technological advances thus seems much less pronounced compared to studies following an occupation-based approach. We further find heterogeneities across OECD countries: while the share of automatable jobs is 6 % in Korea, the corresponding share is 12 % in Austria. The differences across countries may reflect general differences in workplace organisation, differences in previous investments into automation technologies as well as differences in the education of workers across countries.

55. The study demonstrates the necessity to view technological change as substituting or complementing certain tasks rather than occupations. Neglecting the differences in tasks of comparable jobs may lead to an overestimation of job automatibility. Moreover, difference in the task structure are to a large extend able to explain differences in the employment projections.

56. Nevertheless, our figures should be interpreted with caution. Firstly, the approach still reflects technological capabilities rather than the actual utilisation of such technologies, which might lead to a further overestimation of job automatibility. Secondly, even if new technologies are increasingly adopted in the economy, the effect on employment prospects depends on whether workplaces adjust to a new division of labour, as workers may increasingly perform tasks that are complementary to new technologies. Thirdly, the approach considers only existing jobs, although new technologies are likely to create also new jobs. Moreover, new technologies may also exert positive effects on labour demand if they raise product demand due to an improved competitiveness and a positive effect on workers' incomes. Even though this suggests that fewer workplaces are likely to be "at risk" than suspected, differences in automatibility between educational levels are large. This suggests that low educated workers likely will bear the brunt of adjustment costs to technological change in terms of requirements for further training and occupational re-training. Moreover, for this group of workers, regaining the competitive advantage over machines by means of upskilling and training may be difficult to achieve, especially since the speed of the current technological revolution appears to exceed the pace of its predecessors. Hence, this study clearly points towards the need to focus more on the potential inequalities and requirements for (re-)training arising from technological change rather than the general threat of unemployment that technological progress might or might not cause.

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ANNEX

ANNEX A. Descriptive Statistics and Variable Definitions

Table 2. **Descriptive Statistics (unweighted)**

Variable code	Variable content	mean	sd	min	max
gender	Gender	0.472	0.499	0.000	1.000
AGEG5LFS	Agegroup	5.823	2.604	1.000	10.000
education	Education	2.264	0.595	1.000	3.000
pvlit	Literacy	277.447	44.096	119.735	406.088
pvnum	Numeracy	263.608	50.170	74.333	415.966
pvpsl	Problem Solving	279.890	39.473	124.798	411.289
D_Q03R	Sector	0.255	0.436	0.000	1.000
D_Q06aR	Firm Size	1.910	0.558	1.000	3.000
D_Q08a	Responsibility for Staff	0.670	0.470	0.000	1.000
D_Q12aR	Educational Job Requirements	0.377	0.485	0.000	1.000
D_Q12cR	Required Job Experience	0.513	0.500	0.000	1.000
D_Q16aR	Payment Scheme	0.414	0.492	0.000	1.000
G_Q04R	Computer Use at Work	0.224	0.417	0.000	1.000
G_Q06R	Level of Computer Use	0.629	0.483	0.000	1.000
F_Q01b	Cooperating with Others	3.713	1.355	1.000	5.000
F_Q02a	Exchanging Information	0.054	0.047	0.000	0.784
F_Q02b	Training Others	0.024	0.028	0.000	0.269
F_Q02c	Presenting	0.008	0.017	0.000	0.198
F_Q02d	Selling	0.018	0.032	0.000	0.476
F_Q02e	Consulting	0.038	0.031	0.000	0.342
F_Q03a	Planning Own Activities	0.039	0.036	0.000	0.500
F_Q03b	Planning Activities of Others	0.020	0.027	0.000	0.333
F_Q03c	Organizing Own Schedule	0.051	0.041	0.000	0.500
F_Q04a	Influencing	0.030	0.031	0.000	0.267
F_Q04b	Negotiating	0.024	0.028	0.000	0.226
F_Q05a	Solving Simple Problems	0.050	0.038	0.000	0.597
F_Q05b	Solving Complex Problems	0.023	0.024	0.000	0.280
F_Q06b	Working Physically for Long	0.048	0.064	0.000	1.000
F_Q06c	Using Fingers or Hands	0.068	0.063	0.000	1.000
F_Q07a	Not Challenged Enough	0.073	0.260	0.000	1.000
F_Q07b	More Training Necessary	0.788	0.409	0.000	1.000
G_Q01a	Reading Instructions	0.043	0.040	0.000	0.476
G_Q01d	Reading Professional Publications	0.013	0.018	0.000	0.172
G_Q01e	Reading Books	0.008	0.019	0.000	0.323
G_Q01f	Reading Manuals	0.022	0.024	0.000	0.240
G_Q02b	Writing Articles	0.001	0.006	0.000	0.072
G_Q02d	Filling Forms	0.033	0.034	0.000	0.330
G_Q03c	Calculating Shares or Percentages	0.029	0.031	0.000	0.329
G_Q03h	Complex Math or Statistics	0.003	0.011	0.000	0.163
G_Q05c	Internet Use for Work-Related Info	0.035	0.025	0.000	0.269
G_Q05g	Using Programming Language	0.003	0.011	0.000	0.103
G_Q05h	Using Communication Software	0.005	0.013	0.000	0.089
YEARLYINCPRR	Yearly Income (Percentile)	0.330	0.470	0.000	1.000

Source: Authors' calculation based on the Survey of Adult Skills (PIAAC) (2012)

57. The variables are defined as follows:

- Gender dummy: Male (0), Female (1)
- Education: ISCED 0, 1, 2, 3C (short) (1), ISCED 3A-B, 3C (long), 4A-B-C, 5B (2), ISCED 5A 6 (3).
- Sector-dummy: private sector (0), public sector or non-profit organisations (1)
- Firm size / number of employees: 1-10 (1), 11-1000 (2), >1000 (3)
- Responsibility for staff: yes (0), no (1)
- Educational job requirements: ISCSED 0-4 (0), ISCED 5-6 (1)
- Required work experience: less than 1 year (0), at least one year (1)
- Payment scheme: piece or hourly wage or no wage (0), monthly/yearly wage (1)
- Computer use at work: yes (0), no (1)
- Level of computer use: simple (0), moderate or complex (1)
- Not challenged enough at work: yes (0), no (1)
- More training required at work: yes (0), no (1)
- Yearly income (percentile rank): 0 %-10 % (1), 10 %-25 % (2), 25 %-50 % (3), 50 %-75 % (4), 75 %-90 % (5), 90 %-100 % (6).
- Cooperating with others: up to a quarter of the time (0), more than a quarter of the time (1)

58. The task-measures in the PIAAC-data are recorded by the frequency of use. We re-define these data to calculate work-time shares. For this, we first re-define the answers into a work-time scale (e.g. we redefine "less that once a month" as 1/30, "less than once a week" as 1/7, and so on). We then calculate the sum of this across all tasks (for each worker) and divide each task-item by this sum. This way, we receive the share of work time spent on each individual task (assuming that the tasks are not performed simultaneously).

ANNEX B. Estimation results

59. Results for the main model (Model A) are presented in Table 3. The table shows the US estimates of job automatibility as a function of job tasks and other covariates. Note that the coefficients in the table are parameter estimates of a non-linear model, so that they cannot be interpreted as marginal effects. Results for alternative models can be found below.

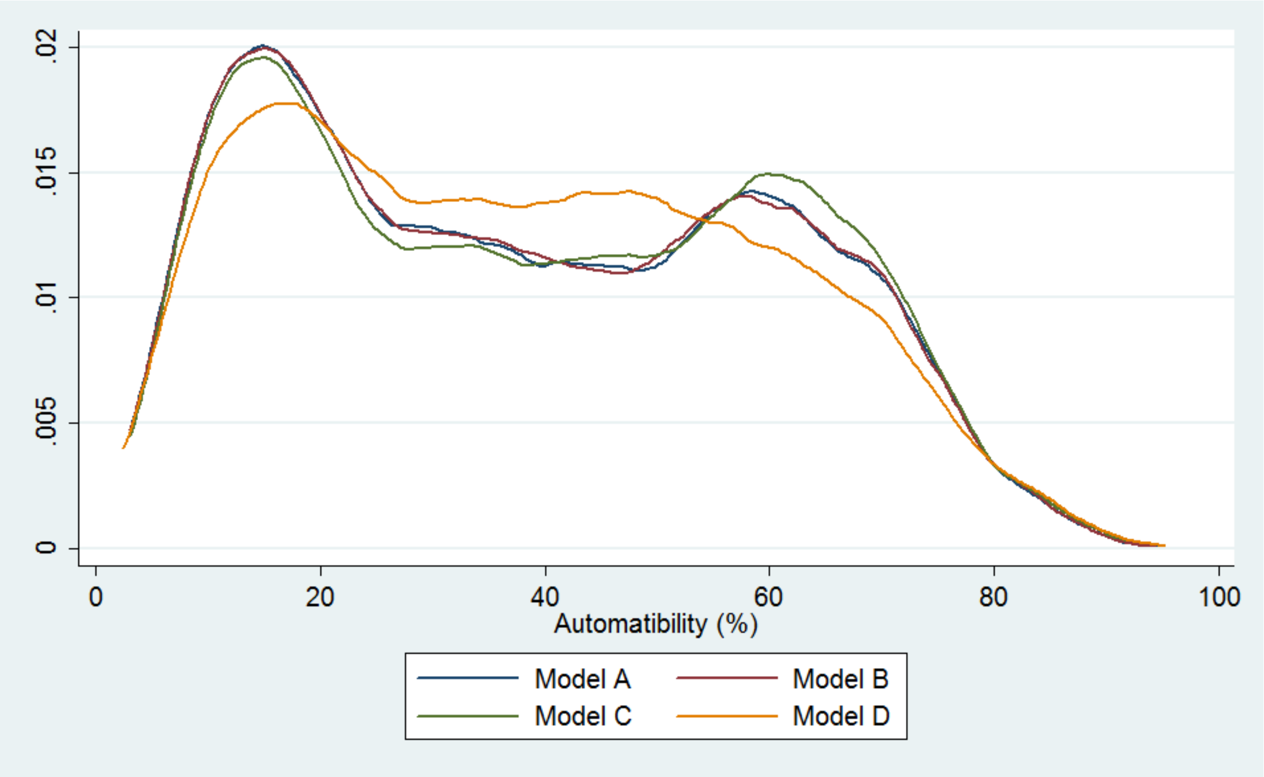
Table 3. **Determinants of job automatibilty (Model A)**

	Variable	Coef.	Std.Err.	p
worker characteristics	gender	-0.034	0.012	0.006
	age group			
	20-24	0.020	0.039	0.614
	25-29	0.161	0.038	0.000
	30-34	0.027	0.038	0.477
	35-39	0.053	0.039	0.168
	40-44	0.100	0.038	0.009
	45-49	0.093	0.039	0.018
	50-54	0.067	0.039	0.083
	55-59	0.077	0.041	0.061
	60-65	0.190	0.041	0.000
	education			
	medium	-0.255	0.035	0.000
	high	-0.497	0.039	0.000
skills	literacy	-0.002	0.000	0.000
	numeracy	0.001	0.000	0.030
	problem solving	-0.001	0.000	0.003
job characteristics	sector	-0.168	0.013	0.000
	firm size			
	11-1000	0.103	0.016	0.000
	>1000	-0.006	0.022	0.794
	responsibility for staff	0.135	0.013	0.000
	educational job requirements	-0.479	0.017	0.000
	required job experience	-0.044	0.013	0.001
	payment scheme	-0.075	0.014	0.000
	yearly income (percentiles)	-0.270	0.014	0.000
	not challanged enough	-0.154	0.020	0.000
	more training necessary	0.061	0.014	0.000
	level of computer use	0.010	0.013	0.475
	cooperating with others	-0.008	0.005	0.094
tasks	exchanging information	0.806	0.220	0.000
	training others	-2.886	0.265	0.000
	presenting	-4.884	0.386	0.000
	selling	2.782	0.235	0.000
	consulting	0.482	0.255	0.059
	planning own activities	-1.785	0.264	0.000
	panning activities of others	-2.052	0.278	0.000
	organizing own schedule	-0.965	0.245	0.000
	influencing	-4.522	0.258	0.000
	negotiating	0.237	0.266	0.373
	solving simple problems	-0.889	0.233	0.000
	solving complex problems	-1.395	0.285	0.000
	working physically for long	-0.709	0.186	0.000
	using fingers or hands	1.085	0.182	0.000
	reading instructions	-1.492	0.192	0.000
	reading professional publica	-4.069	0.369	0.000
	reading books	-4.670	0.340	0.000
	reading manuals	0.261	0.267	0.330
	writing articles	-3.772	1.082	0.000
	filling forms	-0.808	0.203	0.000
	calculating shares or percent	-0.752	0.235	0.001
	complex math or statistics	-1.365	0.495	0.006
	internet use for work-related	-1.036	0.265	0.000
	using programming language	-4.515	0.568	0.000
	using communication softwa	-1.637	0.454	0.000
	constant	1.332	0.084	0.000

Source: Authors' calculation based on the Survey of Adult Skills (PIAAC) (2012)

60. In the main text, the reference model, Model A, is discussed. This model is applied to other OECD countries to extrapolate the automatibility for these countries. As in some of these countries not all variables are included in the PIAAC data, we had to re-estimate the automatibility of tasks for the US with restricted sets of explanatory variables. In total, we estimate 4 models including our reference model (Model A). In Model B we exclude the *Payment Scheme*, in Model C we exclude *Problem Solving Skills* and in Model D we exclude the *Payment Scheme* and the *Educational Job Requirements*. Results for Models A, B, and C are very similar. This is illustrated in Figure 8, which shows kernel density estimates of the predicted automation potential. Only for Model D, results differ noticeable. Model D is based on the selection of variables which are available in the Canadian PIAAC.

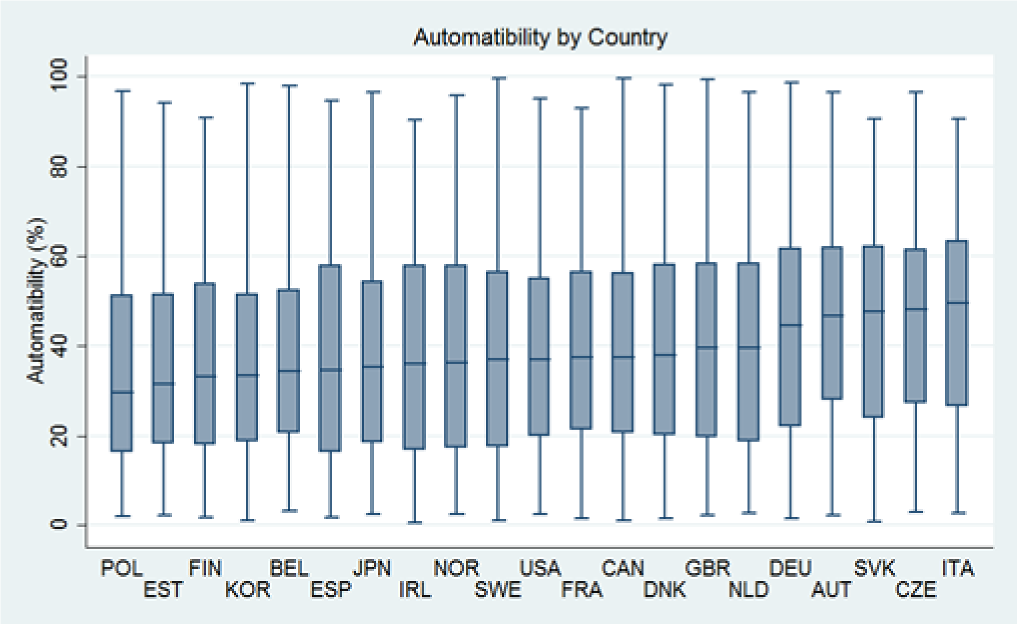
Figure 8. **Distribution of the Estimated Automatibility (USA)**



Source: Authors' calculation based on the Survey of Adult Skills (PIAAC) (2012)

ANNEX C. Detailed Results by OECD Countries

Figure 9. **Distribution of Automatibility by OECD Countries**



Source: Authors' calculation based on the Survey of Adult Skills (PIAAC) (2012)

Table 4. **Automatibility by OECD Countries**

Country	Share of People at High Risk	Mean Automatibility	Median Automatibility
Austria	12%	43%	44%
Belgium	7%	38%	35%
Canada	9%	39%	37%
Czech Republic	10%	44%	48%
Denmark	9%	38%	34%
Estonia	6%	36%	32%
Finland	7%	35%	31%
France	9%	38%	36%
Germany	12%	43%	44%
Ireland	8%	36%	32%
Italy	10%	43%	44%
Japan	7%	37%	35%
Korea	6%	35%	32%
Netherlands	10%	40%	39%
Norway	10%	37%	34%
Poland	7%	40%	40%
Slovak Republic	11%	44%	48%
Spain	12%	38%	35%
Sweden	7%	36%	33%
United Kingdom	10%	39%	37%
United States	9%	38%	35%

Source: Authors' calculation based on the Survey of Adult Skills (PIAAC) (2012)

Table 5. **Share of People with High Automatibility by Education and OECD Countries**

	Share of People at High Risk by Level of Education						
Country	ISCED 1	ISCED 2, 3C(short)	ISCED 3A-B, C(long)	ISCED 4A-B-C	ISCED 5B	ISCED 5A	ISCED 5A, 6
Austria	100%	54%	14%	8%	2%	0%	0%
Belgium	59%	43%	11%	13%	1%	0%	0%
Canada	68%	55%	16%	10%	6%	0%	0%
Czech Republic		55%	12%	9%	8%	2%	0%
Denmark	33%	41%	10%	0%	2%	1%	0%
Estonia		41%	11%	10%	3%	1%	0%
Finland	52%	40%	12%	7%	2%	0%	0%
France	41%	29%	13%		5%	1%	0%
Germany	82%	50%	17%	12%	4%	3%	0%
Ireland	0%	42%	19%	13%	5%	0%	0%
Italy	40%	32%	11%	0%		0%	0%
Japan		28%	15%	3%	7%	1%	0%
Korea	67%	33%	12%		6%	0%	0%
Netherlands	51%	37%	7%		0%	1%	0%
Norway		44%	11%	8%	1%	1%	0%
Poland	25%	48%	13%	9%		3%	1%
Slovak Republic		56%	17%			2%	0%
Spain	56%	43%	15%	7%	5%	0%	0%
Sweden	30%	38%	9%	7%	2%	1%	0%
United Kingdom	49%	40%	14%		4%		1%
United States	100%	44%	19%	8%	6%	1%	0%

Source: Authors' calculation based on the Survey of Adult Skills (PIAAC) (2012)

Table 6. **Share of People with High Automatibility by Income and OECD Countries**

	Share of People at High Risk by Income Percentile					
Country	<10%	10%-25%	25%-50%	50%-75%	75%-90%	90%-100%
Austria	38%	30%	21%	13%	1%	0%
Belgium	17%	11%	10%	2%	1%	1%
Canada	21%	40%	26%	11%	1%	0%
Czech Republic	22%	18%	15%	6%	1%	0%
Denmark	35%	16%	10%	4%	0%	0%
Estonia	14%	19%	11%	6%	0%	0%
Finland	16%	8%	8%	4%	1%	0%
France	0%	21%	15%	7%	0%	0%
Germany	33%	24%	17%	9%	0%	0%
Ireland	27%	26%	23%	10%	0%	0%
Italy	9%	19%	18%	11%	0%	0%
Japan	26%	12%	5%	2%	1%	0%
Korea	21%	13%	6%	2%	0%	0%
Netherlands	33%	26%	14%	8%	1%	0%
Norway	33%	16%	11%	4%	0%	0%
Poland	10%	14%	7%	1%	0%	1%
Russian Federation	0%	4%	3%	1%	0%	0%
Slovak Republic	20%	15%	7%	4%		0%
Spain	25%	29%	21%	8%	2%	0%
Sweden	25%	15%	10%	8%	1%	0%
United Kingdom	32%	23%	16%	5%	0%	0%
United States	19%	31%	17%	8%	0%	0%

Source: Authors' calculation based on the Survey of Adult Skills (PIAAC) (2012)