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**Working Paper**

## The supply of foreign talent: How skill-biased technology drives the skill mix of immigrants. Evidence from Switzerland 1990-2010

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## Working Paper

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The supply of foreign talent:  
How skill-biased technology drives the skill mix of immigrants  
Evidence from Switzerland 1990-2010\*

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**Abstract**

An important goal of immigration policy is facilitating the entry and supply of workers whose skills are scarce in national labour markets. In recent decades, the introduction of information and communication technology [ICT] fuelled the demand for highly skilled workers at the expense of lower skill groups throughout the developed world. In this paper, we show that the skill mix of newly arriving immigrants strongly responded to this shift in the demand for skills. Exploiting the fact that different regions in Switzerland were differentially exposed to ICT due to their pre-ICT industrial composition, we present evidence suggesting more exposed regions experienced stronger growth in relative employment and wage premia for highly skilled workers between 1990 and 2010. We find robust evidence that regions with higher initial ICT exposure experienced a considerably stronger relative influx of highly skilled immigrants. Taken together, these results strongly suggest that immigrants responded to skill-biased changes in economic opportunities. Complementing these findings, we document whether and how the response of immigrants to skill demand changed when Switzerland abolished immigration restrictions for European workers.

**Keywords:** immigrant sorting, international migration; routine-biased technical change; information and communication technology; skill supply;

**JEL-codes:** F22, J61, J24, J31: J23

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# 1 Introduction

International migrants in developed countries are increasingly highly skilled. The number of immigrants with a tertiary degree heading to OECD countries grew by nearly 130% between 1990 and 2010 (OECD, 2013). Within many countries, immigrants are now overrepresented among college graduates and post-graduates, while they are underrepresented among individuals in lower education ranks. Moreover, these immigrants are unevenly distributed not only across destination countries, with four Anglo-Saxon countries (the USA, the UK, Canada, and Australia) accounting for nearly 70% of all high-skilled immigrants in 2010, but also across regions within destination countries (Kerr et al., 2016; Peri, 2016). Understanding the driving forces behind these trends is important, as several studies highlight that the high skilled migrants positively contribute to growth and innovation (Kerr and Lincoln, 2010; Peri, Shih and Sparber, 2015; Ruffner and Siegenthaler, 2016), may have positive effects on the public finances in host countries (Dustmann and Frattini, 2014), and often positively affect natives in the labour market (Beerli and Peri, 2017; Kerr, Kerr and Lincoln, 2015), although some studies also find negative labour market impacts (e.g. Borjas and Doran, 2015). Accordingly, policies facilitating the entry of highly skilled immigrants are popular among policy makers. To give a recent example, British policy makers are considering a withdrawal from the free movement persons [FMP] policy with the EU and replacing it with more selective immigration policies imitating those of top destinations, e.g., Canada or Australia (Guardian, 2017).<sup>1</sup>

In this paper, we analyse whether the share of highly skilled individuals among newly arriving immigrants responds to shifts in the demand for skills induced by information and communication technology [ICT]. ICT is widely believed to have profoundly affected labour markets in OECD countries by fuelling the demand for talent, thereby contributing to an increasing earnings inequality and polarising employment opportunities for workers with different skills (see, Acemoglu and Autor, 2011, for a review). It is less well known, however, how ICT affects immigration flows. Furthermore, there is little evidence improving our understanding how immigration policies affect immigrants' response, if there is any, to these ICT-induced demand shifts. We focus on Switzerland because it provides an excellent example for studying high-skilled immigration. From 1990 to 2010, the country experienced a considerable inflow of immigrants, increasing the share of foreign born citizens from 20% to 29%. Among these, the share of people with a tertiary education grew from 17% to 44%, overtaking the one of natives (25% in 2010), which parallels the Anglo-Saxon experience.<sup>2</sup> Furthermore, Switzerland implemented a free movement policy in 2002, which abolished immigration restrictions for EU citizens but not for those from other parts of the world. This policy change allows us to study whether increased openness to immigration prompted a stronger labour supply response of foreign talent moving to regions with strong skill demand.

To answer whether skill-biased demand affects the skill mix of immigrants, we use census data

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<sup>1</sup>In the UK, the FMP is blamed to have lead to a strong inflow of low skilled immigrants from Eastern European countries. In Germany, discussions center on how to deal with immigration, parties proposing "to attract more highly educated immigrants to plug skill shortage" (Reuters, 2017). Even in the U.S. politicians want to increase selection further by introducing immigration policies like the ones in Canada or Australia over the current family-centred approach (Economist, 2017). In Switzerland, voters approved a referendum in 2014 to abolish the free movement policy with the EU and re-install priority requirements in occupations with high unemployment rates of native workers (Swiss-Government, 2017).

<sup>2</sup>Meanwhile, the share of middle educated remained constant at 26%, while the share of low educated decreased strongly from 57% to 29% (cf. Table 1 below).

detailing the educational attainment of immigrants from an extensive set of origin countries settling in local labour markets.<sup>3</sup> To identify changes in the demand for skilled labour, we exploit the within-country geographical variation in ICT exposure. Local labour markets were specialised to a different degree in occupations with a high routine task content prior to the advent of ICT. Our focus on local labour markets as destinations, where newly arriving immigrants settle, is motivated by testable predictions about the impact of ICT on local economic opportunities (as described by [Autor and Dorn, 2013](#)). Specifically, ICT is hypothesised to substitute for workers employed in occupations with a high routine task content (e.g., clerks, assembly line workers, machine operators) while complementing workers in abstract-intensive occupations, such as managers, professionals, and technicians. As ICT costs fall, firms have higher incentives to substitute routine-intensive employment for (machine) capital and hire workers complementary to ICT. Accordingly, wages and employment should fall in routine-intensive occupations and rise for abstract ones. The impact of ICT on the demand for labour employed in different tasks has a parallel impact on education groups, as we show, routine (abstract) intensive occupations employ mostly workers with intermediate (tertiary) education levels. Thus, ICT increases the economic opportunities of workers with high education levels relative to those with an intermediate education qualification. The effect of ICT on lower educated workers is more ambiguous depending on their specialisation in routine and non-routine intensive occupations and the degree to which income gains of highly educated workers translate into an increase in the demand for low-skilled services (for evidence on this argument, see [Michaels, Natraj and Van Reenen, 2014](#)).

First, we test these predictions about the impact of ICT on labour demand at the level of local labour markets in Switzerland. We exploit that a region’s industry mix in the 1970s strongly determines its specialisation in routine employment in our sample period (from 1990 onwards). This allows us to use a region’s industry specialisation to instrument their specialisation in later decades ([Autor and Dorn, 2013](#)). In line with the predictions above, we find that local labour markets with higher initial routine specialisation experienced a stronger employment growth at the top of the wage distribution and a larger reduction of employment at intermediate ranks. At the bottom of the wage distribution, we find no indication that ICT led to stronger employment growth in highly exposed regions. Additionally, we find evidence for a stronger increase in the wage gap between college and middle educated workers in these regions. Conversely, the wage gap between middle and lower educated workers did not change differentially across regions. We interpret these findings as suggestive evidence that ICT introduction changed the labour market demand for skills and thereby increased the economic opportunities of high-skilled immigrants.

Second, the main contribution of this paper is to show that ICT-induced changes in economic opportunities had a strong impact on the skill mix of newly arriving immigrants. In particular, regions with higher ICT exposure experienced considerably stronger inflow of highly educated immigrants in both decades between 1990 and 2010, while the inflow of middle skilled immigrants was weaker. Our preferred specification suggests that, on average, a 5 percentage point higher local routine specialisation (roughly equal to the cross-region interquartile range) lead to a 14.12% higher inflow of tertiary

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<sup>3</sup>Labor market skills are hard to evaluate directly, we therefore use the educational level of the immigrants, which has the additional advantage to allow more general conclusions about the empirical observation that the high-skilled (educated) share among recent immigrants is rising, we will use skills and education levels interchangeably, hereafter. Likewise, we define commuting zones [CZ] as local labour markets, and use both interchangeably.

educated immigrants relative to those with middle education. On the other side of the skill spectrum, we find a small and statistically insignificant effect on the inflow of immigrants with intermediate education relative to lower educated. This result aligns well with the insignificant change in the relative economic opportunities for the lower skill groups. Investigating the sector heterogeneity of these effects, we find a much more pronounced inflow of highly educated immigrants into the service, compared to manufacturing, sector. We explore numerous alternative explanations for the differential inflow of highly and moderately skilled immigrants including the regional importance of ethnic networks, agglomeration effects, offshoring, and manufacturing decline. None of these factors nor a comprehensive set of sensitivity analyses invalidate our finding, that the skill-biased technical change shifted the skill mix among immigrants in favour of the highly skilled.

Third, we analyse whether and how the response of immigrants change when immigration restrictions are abolished. To this end, we exploit that Switzerland adopted a free movement policy in 2002, which liberalised access to the Swiss labour market for workers from European member states; immigration from other countries continued to be subject to quotas and further restrictions. Using a difference-in-differences strategy, we show that the FMP strongly affected the inflow of EU relative to non-EU immigrants. The inflow of immigrants from EU countries was considerably larger compared to non-EU countries in all education groups. As a result, we cannot reject the hypothesis that the policy-induced inflow was similar in all education groups leaving the skill mix unaffected. Exploring heterogeneous effects by region, we find that the inflow of high-skilled immigrants expanded even more strongly among immigrants from the EU in regions with high ICT exposure. This suggests that the reduction in immigration restrictions even amplified the large immigration response to the ICT-induced demand shift.

Our findings contribute to a growing literature highlighting the sensitivity of migrants' location choices to changing economic opportunities in destinations (Mayda, 2010; McKenzie, Theoharides and Yang, 2014; Ortega and Peri, 2013). By showing that employment opportunities and wages affect not only the scale but also the skills of immigrants, our work is also closely related to Grogger and Hanson (2011). They document two empirical regularities in a large cross-section of immigrants' origin and destination countries. First, immigrants tend to be positively selected, meaning the share of tertiary educated is higher among immigrants than in their respective origin country populations. Second, they find that destinations with higher earnings inequality between skill groups attract more educated immigrants (*positive sorting*). Our findings highlight that skill-biased sorting is very pronounced even within a destination country. Additionally, our results point to the role of ICT an important mechanism explaining why regions with high earnings inequality can attract highly skilled immigrants, which lead to an *accentuation of positive sorting* over recent decades. These findings also complement results found by Gould and Moav (2016), who examine how different levels and sources of income inequality attract immigrants to destination countries.

Our results further add to the literature highlighting the role of immigration as an important channel of local labour market adjustment to economic shocks.<sup>4</sup> Borjas (2001) hypothesised that immigrants “grease the wheel of the labour market” by helping to arbitrage away regional wage

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<sup>4</sup>Relatedly, there are parallels between immigrants and young workers as labour market entrants and suppliers of highly demanded skills. For instance, Autor and Dorn (2009) show that the growth in high-paying abstract occupations as a response to computerisation is largely driven by the entry of young workers in the US.



inequalities. The hypothesis has recently been supported by evidence that immigrants respond to short-run shocks such as the great depression (Cadena and Kovak, 2016) and currency devaluations (Monras, 2015). Our findings underscore how long-run structural changes, such as computerisation, determine job and wage opportunities in local labour markets and strongly influence *with which types of skills* migrants settle in a region. Thus, our analysis also offers a reverse perspective to the work of Lewis (2011), who shows that the inflow of low-skilled immigrants into the US, led to a slower adoption of automation technology in firms. Similar to our study, Basso, Peri and Rahman (2017) explore the response of immigration to computerisation in the U.S. They find that computerisation attracted low-skilled immigrants working in manual-intensive service occupations, thereby reducing the polarisation pressure on native workers. Lastly, studying how ICT-demand interacts with policy changes fits into a larger development in the recent literature focusing on local labour market effects of interactions between different labour demand changes (see, e.g., Gould, 2015, who assesses the interaction between immigration and manufacturing decline).

The remainder of this study proceeds as follows: In Section 2, we lay out the conceptual framework and empirical strategy of our main specifications. In Section 3, we describe immigration policies, settlement structure of immigrants at the beginning of the sample period, the data we use, and present descriptive statistics. In Section 4, we discuss our main results and Section 5 concludes our paper by discussing and reviewing key findings.

## 2 Conceptual Framework and Empirical Strategy

### 2.1 MODELLING MIGRATION MOVEMENTS

To fix ideas, we specify a simple but general gravity model, following Grogger and Hanson (2011) and Ortega and Peri (2013).<sup>5</sup> Let the (log) number of individuals with skill  $j$ ,  $\ln N_{rst}^j$ , migrating from source country  $s$  to destination region  $r$  in time  $t$  be a function of three skill-specific and general vectors: destination characteristics  $v_{rt}^j$  such as skill-specific wages, employment possibilities, or the region's general amenities; source country characteristics  $u_{st}^j$  such as wages, political stability, and supply of skills; destination-by-source characteristics  $x_{rst}^j$ , most commonly considered the pecuniary and non-pecuniary costs of migrating from  $r$  to  $s$ , such as source-country and skill-specific immigration restrictions or psychological costs of moving. Each of these vectors may include time-varying and constant factors. We write

$$\ln N_{rst}^j = v_{rt}^{j'}\tau + u_{st}^{j'}\delta + x_{rst}^{j'}\beta, \quad (1)$$

where  $j = 1, 2, 3$  denotes low, middle, or highly skilled individuals. The coefficient  $(\tau, \delta, \beta)$  vectors govern the direction of the various factors, i.e. higher skill-specific wage premia at the destination,  $w_{rt}^j$  would, *ceteris paribus*, increase the number of immigrants with these skills, i.e.  $\tau_{wage} = \frac{\partial \ln N_{rst}^j}{\partial w_{rt}^j} > 0$ .

In this study, we focus on the effects on different skill groups. Hence, we cancel common factors influencing immigrants destination choices across the skill distribution by differencing  $j$  and  $j - 1$ ,

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<sup>5</sup>A more detailed version of the model is derived in Appendix B. See also Cadena and Kovak (2016) for a similar approach and Beine, Bertoli and Fernández-Huertas Moraga (2016) for a recent survey of the motivation and micro-economic foundation of gravity models in migration research.

such that

$$\ln \frac{N_{rst}^j}{N_{rst}^{j-1}} = \tilde{v}_{rt}'\tau + \tilde{u}_{st}'\delta + \tilde{x}_{rst}'\beta, \quad (2)$$

where each vector on the right-hand side represents skill-related differences, e.g.,  $\tilde{v}_{rt} = v_{rt}^j - v_{rt}^{j-1}$ , such as the skill premium in destination  $r$  and time  $t$ . Variables affecting both skill groups similarly, such as generally high wage levels, are canceled in (2). To study changes over time, we take first-differences of equation (2),

$$\Delta \ln \frac{N_{rst}^j}{N_{rst}^{j-1}} = \Delta \tilde{v}_{rt}'\tau + \Delta \tilde{u}_{st}'\delta + \Delta \tilde{x}_{rst}'\beta, \quad (3)$$

where  $\Delta \tilde{v}_t$  denotes time differences, i.e.  $\tilde{v}_{t+1} - \tilde{v}_t$ . This eliminates time constant factors from each vector, e.g., constant amenities, bilateral geographic distances, language, or culture. Thus, growth in the relative number of individuals from two skill groups is a function of *skill-specific changes* in push- and pull-factors as well as changes in bilateral migration costs. For example, setting  $j = 3$  in equation (3)  $\tau > 0$  would predict a greater inflow of highly skilled relative to middle skilled migrants in destinations that experience, *ceteris paribus*, a greater increase in the college skill premium.

## 2.2 EXPOSURE TO ICT

Our main interest lies in estimating  $\tau$ , i.e. the effect of economic opportunities in destinations  $\Delta \tilde{v}_{rt}$  on the growth of the skill mix of immigrants  $\Delta \ln \frac{N_{rst}^j}{N_{rst}^{j-1}}$ . The standard approach in the literature is to estimate equation (2) using differences in income levels between skill groups, both in destinations,  $\tilde{v}_{rt} = (w_{rt}^j - w_{rt}^{j-1})$ , and origin countries,  $\tilde{u}_{st} = (w_{st}^j - w_{st}^{j-1})$ , and proxies or high-dimensional fixed effects to absorb bilateral migration costs,  $\tilde{x}$ , (see, *inter alia*, Bertoli and Fernández-Huertas Moraga, 2013; Grogger and Hanson, 2011). In contrast, we exploit the impact of ICT as a plausibly exogenous and skill-biased demand shock in Swiss local labour markets, by focusing on labour markets within a country this also allows muting several potential confounders associated with location choice of a more diverse set of destinations as in cross-country comparisons. Based on testable predictions from a large body of literature on ICT and job polarisation, we hypothesise that ICT affected economic opportunities in Swiss local labour markets differently due to their heterogenous specialisation in routine-intensive employment in the pre-ICT era.<sup>6</sup>

This hypothesis is based on the idea that ICT substitutes for workers employed in occupations with a high content of routine cognitive or routine manual tasks, such as assembly line workers or bank clerks who, typically, had an intermediate wage level. Conversely, ICT complements workers in managerial or professional occupations, typically entrusted with non-routine, abstract or problem-solving tasks at the top of the wage distribution. Thus, the advent of ICT and the continuous fall of its cost has lead firms to substitute ICT for routine workers, driving down their wages and employment opportunities.

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<sup>6</sup>The idea of routine intensity as a proxy for relative demand shifts affecting the wage differential of workers with different educational backgrounds and skills has found wide application in the literature on skill-biased technical change and job polarisation. See Acemoglu and Autor (2011) for an overview of the relevant literature. After Autor, Levy and Murnane (2003)'s seminal contribution showing wage and employment trends of workers with different routine-task content in their jobs for the U.S., similar trends were documented for the U.K. (Goos and Manning, 2007), Europe (Goos, Manning and Salomons, 2014), and Germany (Dustmann, Ludsteck and Schönberg, 2009; Spitz-Oener, 2006).

Yet, demand for workers in abstract occupations surged, increasing their wages and employment rates. Evidence of these mechanisms are presented by [Autor and Dorn \(2013\)](#), who show that local labour markets in the US with a larger historical share of workers employed in routine occupations experienced larger wage and employment growth at the top, relative to the middle of the wage distribution. In addition, [Michaels, Natraj and Van Reenen \(2014\)](#) present evidence that the impact of ICT on the demand for workers employed in different occupations has a parallel impact on workers with different education levels, which we confirm for the Swiss labour market below. Workers with an intermediate (secondary) education level were more intensively employed in routine occupations, while those with a college education mostly worked in abstract occupations. ICT adoption, therefore, lowered the demand for the first group and increased it for the latter. The effect on less educated people, on the other hand, is ambiguous since those were employed in a mix of routine and non-routine manual tasks.

We measure a local labour market’s exposure to the impact of ICT, by its *beginning of period* specialisation in routine-intensive occupations, i.e., the share of routine-intensive employment [*RSH*]. To this end, we merge measures of an occupation’s intensity in three tasks (routine, manual, abstract) available in the [US Department of Labor, Employment and Training Administration \(1977\)](#)’s Dictionary of Occupational Titles (DOT) with occupations in the Swiss census data.<sup>7</sup> Constructing the routine intensity measures, we closely follow [Autor and Dorn \(2013\)](#) to allow comparability with the previous literature and the US context. We combine the task measures from the DOT to create an indicator of routine-intensity by occupation,

$$RTI_{kt_0} = \ln(T_{k,t_0}^R) - \ln(T_{k,t_0}^M) - \ln(T_{k,t_0}^A) \quad (4)$$

where  $T_{k,t_0}^R$ ,  $T_{k,t_0}^M$ , and  $T_{k,t_0}^A$  denote an occupation  $k$ ’s intensity in routine, manual, and abstract tasks in the base period  $t_0$ , here 1980. Each task is measured on a one to ten scale, with ten meaning that the task is most heavily used in this occupation. Therefore, the constructed index,  $RTI_{k,t_0}$ , rises if routine tasks are used more intensively in an occupation and falls with the use of manual and abstract tasks. For each local labour market, we then calculate the employment share in routine-intensive occupations,

$$RSH_{rt} = \left( \sum_{k=1}^K L_{rkt} \times 1[RTI_{k,t_0} > RTI_{t_0}^{P66}] \right) \left( \sum_{k=1}^K L_{rkt} \right)^{-1},$$

where  $L_{rkt}$  is the employment in occupation  $k$  in region  $r$  and decade  $t$ .  $1[.]$  takes a value of one if occupation  $k$  is in the top employment-weighted third (66 percentile) of the routine task-intensity distribution.<sup>8</sup>

Given that a region’s initial routine share can proxy the extent that firms replaced workers with a high routine tasks load (e.g., clerical work, bank telling, repetitive production tasks, or monitoring activities) in response to ICT availability. The associated testable prediction from the literature summarised above is that Swiss local labour markets with a larger initial share of routine employment

<sup>7</sup>[Autor and Dorn \(2013\)](#) provide a measure for routine, abstract and manual task content for US 2000 census occupations (occ2000) from the DOT 1977. These three task aggregates were collapsed from originally five task measures first used in [Autor, Levy and Murnane \(2003\)](#). We use a crosswalk from the US National Crosswalk Service Center to match these variables to the International Standard Classification of Occupations (ISCO-88) available in the Swiss census.

<sup>8</sup>The choice of the 66 percentile and the log aggregation are ad hoc, but have been implemented in several contexts and shown to be robust to variations by [Autor and Dorn \(2013\)](#).

experience larger positive demand shifts for high relative to middle educated workers, while the demand shifts between middle and low is ambiguous or close to zero:

$$\frac{\partial \Delta (v_{rt}^3 - v_{rt}^2)}{\partial RSH_{rt}} > 0 \quad \text{and} \\ \frac{\partial \Delta (v_{rt}^2 - v_{rt}^1)}{\partial RSH_{rt}} \approx 0.$$

Below, we provide suggestive evidence that both hypotheses are likely to be satisfied in our dataset and application.

### 2.3 EMPIRICAL APPROACH AND IDENTIFICATION

In sum, we estimate models of the form

$$\Delta \tilde{y}_{rsct}^j \equiv \Delta \ln \frac{N_{rst}^j}{N_{rst}^{j-1}} = \tau RSH_{rt} + \Delta \tilde{x}_{rst}^j \beta + \alpha_c + \alpha_{st} + \varepsilon_{rsct}, \quad (5)$$

where the parameters are allowed to be  $j$ -specific (by estimating the models separately for high versus middle and middle versus low skilled). Accordingly, our key parameter of interest  $\tau^j$  measures the degree to which Swiss local labour markets with higher initial routine share experience larger growth in the number of individuals with the higher education level  $j$  relative to those with a lower education level ( $j - 1$ ). First, we expect ICT to lead to larger inflows from highly relative to middle educated immigrants,  $\tau^3 > 0$ . Second, we expect ICT to have a small or zero effect on the relative inflow of middle relative to low educated immigrants,  $\tau^2 \approx 0$ .

In contrast to eq. (3), source country effects,  $\Delta u_{st}^j$ , are absorbed by the full set of source-by-decade fixed effects,  $\alpha_{st}$ , which also account for any differences across decades, which is important as we stack the two first-difference regressions (cf. [Autor and Dorn, 2013](#); [Autor, Dorn and Hanson, 2013](#)). Canton fixed effects,  $\alpha_c$ , account for trends in attractiveness associated with, for example, regional institutional and cultural differences.<sup>9</sup> Conditioning on canton fixed effects implies that the identifying variation of our ICT shock comes from within-canton variation of  $RSH_{jt}$ .<sup>10</sup> Exploiting exposure to ICT as a quasi-exogenous shock to local economic opportunities allows us to isolate the response of high-skilled immigration to computerisation ([Autor and Dorn, 2013](#)).

This approach has two advantages compared to using local wage differences as measures for a region's attractiveness. First, wage differentials may be endogenously driven by immigration.<sup>11</sup> Second, demand-induced changes in economic opportunities might only partly be reflected in wage changes while in many examples the bulk of adjustment is via employment (see [Cadena and Kovak 2016](#) for a similar argument). We overcome both issues by exploiting the impact of ICT as a plausibly ex-

<sup>9</sup>Switzerland's political or administrative subdivisions are called cantons.

<sup>10</sup>We present the within and between canton variation in Appendix Table A1, the within variation is as large or larger than the between canton variation, we also present maps of Switzerland depicting the geographical distribution of the routine share across decades, cf. Appendix, Figure A2.

<sup>11</sup>Depending the complementarities between natives and immigrants from both groups, inflows of highly skilled immigrants could either increase or decrease the wage premium for college education over secondary education. Indeed, [Beerli and Peri \(2017\)](#) find evidence for complementarity. They exploit that the implementation of the free movement policy between Switzerland and the EU created a plausibly exogenous supply shock of mostly high-skilled cross-border workers. The inflow of cross-border workers increased the wages of tertiary educated natives and left the wages of middle educated natives unaffected.

ogenous shift to local skill demand and, thus, skill-related economic opportunities (reflected in both wages and employment). We use an instrumental variable strategy to isolate the long-run, quasi-fixed component of a local labour market’s current routine share (Autor and Dorn, 2013). That is, we use the industry composition of regions in the first available Swiss census in 1970 as instruments for the observed routine share in later decades:

$$\widetilde{RSH}_{r1970} = \sum_i \frac{L_{ir1970}}{L_{r1970}} \times RSH_{i-r1970}, \quad (6)$$

where  $\frac{L_{ir1970}}{L_{r1970}}$  represents employment in industry  $i$  as a share of total employment in region  $r$  in 1970.  $RSH_{i-r1970}$  is the routine share of employment in industry  $i$  in all regions except  $r$  in 1970 (summary statistics can be found in Table A1, in the Appendix). The first stage results are strong and suggest that the region’s industry composition in 1970 strongly relates to its composition in later years.<sup>12</sup>

### 3 Data, institutions, and descriptive statistics

#### 3.1 DATA SOURCES

Our main data source is the full resident-population census of Switzerland, 1990 and 2000, and in its successor the Structural Survey, a yearly micro-census from which we pool the years 2010-2012.<sup>13</sup> We classify individuals as *new immigrants* (we will use new and recent immigrants interchangeably hereafter), if they were born abroad, arrived less than 5 years prior and resided in Switzerland in the census year. We focus on new immigrants, rather than the total of foreign born, as they represent the “marginal international migrant”.<sup>14</sup> Thus, they are most affected by the forces discussed in this paper. Among new immigrants, the census allows distinguishing 33 different *origin countries* based on the country of residence 5 years prior to the census.<sup>15</sup> Individuals are classified into three education groups using the International Standard Classification of Education (ISCED). *Highly educated* individuals hold a tertiary degree (ISCED 5 and 6), whereas *middle educated* individuals hold a degree from a secondary school (ISCED 3 and 4). *Low educated* individuals are those with compulsory education only or less (ISCED 0, 1 and 2). As *destinations*, or local labour markets, we use the 106 Swiss

<sup>12</sup>The results, presented in Appendix Table A3, show that the routine employment in local labour market industrial composition in 1970 is strongly significant and highly predictive of the share in both decades, and when stacking them. The F-statistics are well beyond conventional rules of thumb. For each percentage point increase in the historical share, the contemporaneous share rises by approximately half a percentage point. Moreover, the historical routine share can explain roughly 70 percent of the geographical variation in the routine share, as indicated by the R<sup>2</sup>s.

<sup>13</sup>In contrast to the census, which constitutes a complete count of the population, the Structural Survey represents a 3% sample of the total resident population (Swiss Federal Statistical Office, 2011). We pooled the structural surveys from 2010 to 2012 to gain more accuracy. When necessary, observations from the Structural Survey are weighted using the official sampling weights.

<sup>14</sup>Note that this definition of new immigrants does not include cross-border workers (CBW) since the census only covers individuals based on Swiss residence. CBW constitute roughly 5% of the entire workforce but are only present in regions close to the Swiss border (see Beerli and Peri, 2017). We find similar effects of ICT on this group’s skill mix but abstract from them in the analysis for data consistency reasons.

<sup>15</sup>For 2010 to 2012, the information on the year of arrival is missing in some entries. In this case, we classified foreign-born residents as recent immigrants if they had a short-term residency permit (B, L). Using the last residency country reflects more closely the immigration decision – in the Grogger and Hanson (2011) sense – compared to using the country of birth as origin. However, the correlation between the two classifications of origin is very high in our sample. As the census does not distinguish different places of origin for immigrants from Ex-Yugoslavia, we aggregate immigrants from all available countries of former Yugoslavia in the Structural Surveys 2010-2012. We proceed similarly with immigrants from the Czech Republic and Slovakia.

commuting zones (CZs) as defined by the FSO ([Schuler, Dessementet and Joye, 2005](#)); these CZs are constructed such that the majority of people commute to work within its boundaries.

Our base sample consists of the *population* of new immigrants, older than 15 years of age with non-missing information in education and place of residence. When the focus is on workers rather than the population, we restrict attention to immigrant workers aged 18-64. We then aggregate these into year, CZ, origin country, and education group cells and deal with the presence of zero or missing bilateral migration stocks by adding one to all cells. This is done in order to prevent sample selection due to zero-migration flows (when using log numbers) and to keep a consistent sample throughout ([Ortega and Peri, 2013](#), use the same approach).<sup>16</sup> Differencing across decades leaves us with a sample of 6,996 observations (2 decades  $\times$  33 origin countries  $\times$  106 CZs).<sup>17</sup>

In Section 3.4, we use two additional datasets to measure the impact of ICT on economic opportunities by skill type in Swiss local labour markets. First, we use the Swiss Earnings Structure Survey (SESS) to illustrate the effect of ICT on mean hourly wages by education group. The SESS collects labour market and demographic information of individuals employed in a representative sample of private sector companies biannually between 1994 and 2010. We restrict the sample to all employees (natives and immigrants) with non-missing information regarding wages, hours worked, place of work, and basic demographic variables.<sup>18</sup> We complement this data with the Swiss labour Force Survey (SLFS) that allows measuring wages at the level of detailed ISCO occupations. Using the same sample restriction as for the SESS, we compute the average log hourly wage for each ISCO occupation to measure skill rank in the pooled SLFS sample covering 1991-1993, as explained in more detail below.

In Section 4.3, to analyse the impact of the policy, we replace the source-by-decade fixed effects by a rich set of factors controlling for time-varying source country push drivers. In particular, we include proxies for the change in skill supply when computing the population size of education groups in each origin country based on data from [Barro and Lee \(2013\)](#).<sup>19</sup> To create a proxy for wage differences between education groups in origin countries we use Gini coefficients from the UNU-WIDER World Income Inequality Database.<sup>20</sup> As additional controls, we use per capita GDP ([Heston, Summers and Aten, 2011](#)) and a country's polity IV score as a measure for civil rights protection and democratisation ([Marshall, Gurr and Jagers, 2014](#)). To measure exposure to civil conflict, we retrieve information

<sup>16</sup>Bilateral stocks should be positive in expectation, though some might be very small and zero migration stocks may occur in finite populations if bilateral migration probabilities are very small. To assess the sensitivity of this approach, we replace the missing values due to  $\ln(0)$  with 0 and include an indicator variable for those cases. Results are robust to this variation, cf. Appendix Table A4. Additionally, in a previous version of this paper, we assessed the impact of  $RSH_{rt}$  on the education shares which do not suffer from this problem; all substantive conclusion remain valid.

<sup>17</sup>One origin country category subsumes missing origin information. Due to the rich number of fixed effects, their impact on our main results is negligible, however, we present robustness to dropping these from the sample, cf. Appendix Table A4.

<sup>18</sup>We drop individuals with real hourly wages below the 1st and above the 99th percentile of the wage distribution each year to avoid effects from outliers.

<sup>19</sup>[Barro and Lee \(2013\)](#) report population size and the percentage of the population in different levels of educational attainment for a large set of countries between 1950-2010. We define 'no schooling attainment' and 'primary schooling attainment' as *low educated*, 'secondary schooling attainment' as *middle educated* and 'tertiary schooling attainment' as *highly educated*. We use the aggregate of Croatia, Serbia and Slovenia to calculate the education measure for 'Ex-Yugoslavia' and of the Czech Republic and Slovakia for measure of 'Czechoslovakia'.

<sup>20</sup>We use Version 2.0c (May 2008). Generally, we only included inequality measures based on disposable income. As there were numerous sources for Gini coefficients for some countries, we computed averages for a given country-year cell. The averaging resulted usually in little differences compared to relying only on a single datasource. For other countries such as China or India, inequality measures based on disposable income were scant or unavailable. In these cases we also included studies that calculated Gini coefficients based on consumption or net income data.



related to whether a country was exposed to conflict in a decade with at least 25 battle-related fatalities from Armed Conflict Dataset ([UCDP/PRIO, 2015](#)).

### 3.2 IMMIGRATION POLICY BACKGROUND

Switzerland gradually implemented important changes to its immigration policy after 2002, about mid-way through our analysis period of 1990 to 2010.<sup>21</sup> Prior to this date, people from all origin countries who wanted to work and reside in Switzerland had to apply for a resident permit. Permits were subject to global yearly quotas set by the federal government and distributed to cantons proportionally based on population size. Cantonal immigration offices granted permits only if no equally qualified native could be found for a given job vacancy, putting a high administrative load on employers and, consequently, reducing incentives to employ foreign labour. Immigrants from EU17 and EFTA countries were granted priority in awarding permits while migrants from other countries (including those from the US or Canada) were required to be “highly qualified”.<sup>22</sup> The implementation of the free movement of persons (FMP) policy with the EU after 2002 gradually liberalised access for EU workers to the Swiss labour market. Residency in Switzerland remained conditional on employment but restrictions on employment were gradually and fully abolished. First, they were abolished first for EU17 countries in 2007 and then, in 2011, for eastern European member states (EU8 and EU2). For other, non-European origin countries, all restrictions remained similar to those of the 1990’s.<sup>23</sup> We interpret the FMP implementation as an exogenous change to migration restrictions. In fact, accepting the FMP policy as one of the EU’s central pillars, was a necessary concession made by Switzerland to pass a larger package of bilateral agreements.<sup>24</sup>

Table 1 shows the number of new immigrants by origin country group (EU and non-EU) and education level.<sup>25</sup> In 1990, roughly 60% of all new immigrants arrived from European countries (old and new member states). Between 1990 and 2010, the number of new arrivals from the EU increased considerably, while the corresponding number from non-EU countries decreased slightly. Thus, by 2010, immigrants from EU countries constituted 80% of all new arrivals (a 21 percentage point increase). In contrast to the absolute numbers, the change in skill mix of EU and non-EU countries was remarkably similar. Both origin groups experienced a strong decrease in the share of low educated and a corresponding increase in the share of highly educated individuals. Also, the share of middle educated remained roughly constant in both groups. Although the levels are different, the changes in high-to-middle skilled shares are very similar, already suggesting a similar response to the local pull factors.

<sup>21</sup>Here, we focus on immigration patterns and policy relevant to our sample period; more information from prior to the sample period is summarised in [Kunz \(2016\)](#).

<sup>22</sup>“High qualification” mainly meant “managers, specialists and qualified professionals”, however, it was deliberately defined broadly to also include investors, workers who specialised in the construction of certain facilities (e.g., tunnels), or those with “special knowledge” ([Bundesrat, 1991, 2002](#)). EU17 countries include Belgium, Germany, France, Italy, Luxembourg, Netherlands, Denmark, Ireland, United Kingdom, Greece, Portugal, Spain, Finland, Austria, Sweden, Cyprus, and Malta, while EFTA stands for Iceland, Norway, and Liechtenstein.

<sup>23</sup>EU8 includes Estonia, Latvia, Lithuania, Poland, Slovakia, Slovenia, Hungary, and the Czech Republic. EU2 includes Romania and Bulgaria.

<sup>24</sup>The FMP policy’s limited popularity was a major reason why the entire bilateral package had to go through a national referendum vote in May 2000 (see, [Bundeskanzlei, 2000](#)), in which it was approved, and why the Swiss population voted in favour of reintroducing immigration restrictions in February 2014 (see, [Bundeskanzlei, 2014](#)). See Appendix C for more details on the policy.

<sup>25</sup>Table A2 in the Appendix provides basic summary statistics for the full list of origin countries in our sample.

**Table 1:** SKILL MIX OF NEW IMMIGRANTS BY ORIGIN COUNTRY GROUP

Origin			Educ. group share			Educ. group ratio	
country	# new	Origin				high/	middle/
group	immigrants	share	high	middle	low	middle	low
Panel A: 1990							
EU	125,576	0.59	0.19	0.30	0.51	0.65	0.59
Non-EU	85,875	0.41	0.13	0.23	0.64	0.55	0.36
All origins (incl. missing)	233,912		0.17	0.26	0.57	0.63	0.46
Panel B: Change 1990-2010							
EU	196,482	0.21	0.29	-0.02	-0.27	1.06	0.61
Non-EU	-8,173	-0.21	0.23	0.01	-0.24	0.94	0.24
All origins (incl. missing)	234,356		0.27	0.00	-0.28	1.05	0.89

*Notes:* All origins also include missing information on origin countries, hence EU plus non-EU are less than the total number of immigrants.

*Source:* Swiss census 1970, 1990-2010, own calculations.

Although changes in educational attainment in the origin countries of immigrants are fully absorbed in our empirical specification through source-by-decade fixed effects, a natural question is to which degree the educational attainment among immigrants simply resemble those in their origin. In Table A5, we present the average education attainment in EU and non-EU countries using data from Barro and Lee (2013).<sup>26</sup> We compute the average education group shares of EU and non-EU countries using the number of new immigrants each decade in Switzerland as weights. In both EU and non-EU, the share of low educated fell almost equally as in the population of their country of origin. Quite differently, however, was the gain in the upper two education groups. While the population share with a middle education grew strongly in immigrants' home countries, it stagnated among immigrants in Switzerland. In contrast, the share with a college education grew three to four times faster among immigrants than their respective country populations. Thus, this strongly suggests the mechanical change in the source populations cannot explain the trends among new immigrants in Switzerland.

### 3.3 CHARACTERISTICS OF LOCAL LABOUR MARKETS AND TASK-BASED SPECIALISATION OF EDUCATION GROUPS

To understand the changes in immigration due to computerisation, we analyse immigration into Swiss commuting zones (CZs) with different levels of exposure to ICT. Table 2 presents descriptive summary statistics, separately for CZs above and below the regional median routine share in 1970, i.e.  $\widetilde{RSH}_{j,1970}$  (as defined by equation, 6). A few facts are noteworthy. First, high routine CZs represent a larger share of total Swiss employment throughout all years. Second, both types of regions have a different industrial composition. A lower share of total employment is employed in agriculture/mining and construction/utilities while they have a higher share in high-tech manufacturing and services. This highlights – similar to the US experience (Autor and Dorn, 2013) – that regions with high routine intensity are not only those with a high manufacturing share but also regions with specialisation in knowledge intensive services (see also the map in Figure A2). Third, the wage levels for all three

<sup>26</sup>Barro and Lee (2013) provide population share of (completed) educational attainment (similarly defined in the Swiss census and same age range) by country. Note that we get qualitatively similar results if we compare educational attainment between immigrants and the origin country population separately for different age groups (e.g. age 15-35, 36-55, > 55).



education groups are higher in CZ with higher initial routine specialisation; yet, wage inequality between education groups is larger. For instance, highly (middle) educated earn roughly 20 (8) Swiss Francs more per hour than middle (low) educated whereas the same gap is 16 and 6 Swiss Francs in low routine regions in 1990. Fourth, consistent with higher earnings for more educated workers, higher routine regions had a higher share of tertiary educated immigrants *already* in 1990. Lastly, the time dimension in the table reveals that both regions employment reduced during the 1990s, and strongly expanded between 2000 and 2010.

**Table 2:** CHARACTERISTICS OF HIGH AND LOW ROUTINE REGIONS 1990-2010

	CZs above median $\widetilde{RSH}_{r1970}$			CZs below median $\widetilde{RSH}_{r1970}$		
	Level	Changes		Level	Changes	
	1990	1990-2000	2000-2010	1990	1990-2000	2000-2010
# total employment	2,033,934	-219,023	537,657	675,576	-11,252	260,756
Share high routine occupations (%)	0.34	-0.02	-0.03	0.30	-0.01	-0.02
<i>Industry shares</i>						
Agriculture/Fishing/Mining (%)	0.03	0.00	-0.00	0.08	-0.01	-0.03
High-tech manufacturing (%)	0.10	-0.02	-0.01	0.08	-0.01	-0.01
Low-tech manufacturing (%)	0.10	-0.02	-0.02	0.12	-0.02	-0.02
Construction/Utilities (%)	0.09	-0.02	0.00	0.11	-0.02	0.00
Knowledge intensive services (%)	0.34	0.08	0.03	0.26	0.06	0.04
Less Knowl. intens. services (%)	0.34	-0.02	-0.00	0.34	-0.00	0.00
<i>Wage structure (in CHF)</i>						
Hourly wage highly educated	55.88	0.55	1.68	48.07	0.78	1.48
Hourly wage middle educated	35.58	0.46	0.05	31.68	0.83	0.75
Hourly wage low educated	27.43	0.33	0.28	25.67	0.48	1.33
Wage difference high vs middle	20.30	0.09	1.63	16.39	-0.05	0.73
Wage difference middle vs low	8.15	0.13	-0.23	6.01	0.35	-0.58
<i>New immigrants</i>						
# new immigrants	180,300	-39,275	230,289	53,612	-20,049	63,391
Share highly educated (%)	0.18	0.22	0.07	0.12	0.16	0.05
Share middle educated (%)	0.26	-0.02	0.01	0.27	-0.00	0.05
Share low educated (%)	0.56	-0.20	-0.08	0.61	-0.15	-0.10

*Notes:* Total employment based on 18-64 year olds. OCC Eurostat classification of industries are used to define industries. Agriculture/Fishing/Mining comprises NACE Rev 1.1. industries 01, 02, 05, 10-14. High-tech manufacturing is NACE Rev 1.1 industries 24, 29, 30, 31, 32, 33, 34 and 35 excluding 35.1. Low-tech manufacturers are the remainder manufacturing categories. Knowledge-intensive services are NACE Rev 1.1 industries 61, 62, 64, 65-67, 70-74, 80, 85, 92. Wages correspond to real log hourly wages in 2010 Swiss Francs.

*Source:* Swiss census 1970, 1990-2010, SESS 1994-2010, SAKE 1991-2010, own calculations.

For ICT to have differential effects on workers with different education levels, they need to cluster in occupations with different task content. Table 3 shows – using US DOT data and the Swiss census data from 1990 – that this is indeed the case. The average task content of workers’ occupations for the three education groups is shown separately for the total workforce (Panel A) and for new immigrants (Panel B). Panel A highlights that highly educated workers cluster in occupations with a high abstract task content and both low routine and manual task content. The occupational specialisation of workers with a middle education has above average routine task content and below average abstract and manual task content. Lastly, as expected, low skilled workers are most heavily employed in occupations with a high manual task content. In contrast to highly skilled workers, however, these workers have only slightly below average routine task content. If ICT only replaced routine tasks, both high and low educated workers should benefit at the expense of those in the middle. Yet, as Autor, Levy and Murnane (2003) argue, ICT complements non-routine tasks, particularly abstract, cognitive tasks.

ICT should benefit high educated workers who typically work in abstract occupations but not middle or low educated workers who both lack large abstract task contents. Overall, this suggests that ICT increases the demand for highly educated workers at the expense of middle educated workers and has ambiguous effects on those with lower skills.

**Table 3:** DESCRIPTIVE TASK CONTENT OF EDUCATION GROUPS IN 1990

Education Group	Task Content			
	abstract	routine	manual	RTI
<i>Panel A: Total Workforce</i>				
High	0.79	-0.32	-0.19	-0.31
Middle	-0.10	0.12	-0.06	0.11
Low	-0.44	-0.05	0.34	-0.03
<i>Panel B: Recent Immigrants</i>				
High	0.72	-0.16	-0.16	-0.26
Middle	-0.41	0.25	0.34	-0.06
Low	-0.70	0.08	0.61	-0.09

*Notes:* Task measures taken from DOT data as described in Section 2.2. Routine intensity (RTI) calculated as in Equation (4). Task measures and RTI scores are first standardised to have mean zero and standard deviation one in the entire workforce in 1990. Then, averages are computed over all workers in an education group using employment weights. Agricultural workers have been omitted from this table.

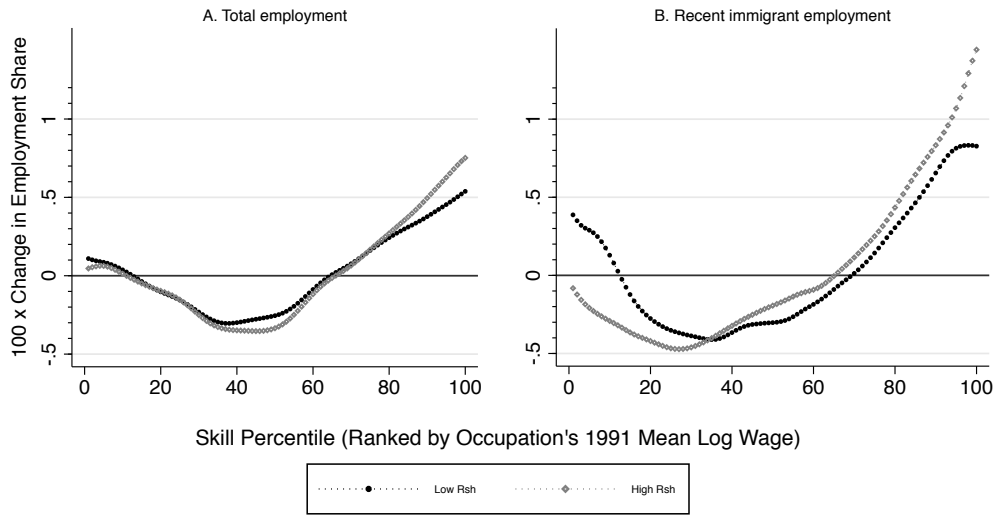
*Source:* Swiss census 1990, own calculations.

It has been suggested that newly arriving immigrants tend to downgrade in the wage or occupation structure compared to natives with similar education levels (Dustmann, Schönberg and Stuhler, 2016). Table 3 shows the task specialisation by education group separately for new immigrants in 1990 in Panel B. In our data, highly educated immigrants exhibit similar specialisation patterns as observed for the total workforce although their abstract task content is slightly lower and routine task content higher. Middle educated immigrants have very low abstract, yet high routine and manual tasks levels. Low educated immigrants, in turn, show a low specialisation in cognitive abstract, high specialisation in manual tasks (both more extreme than for the total workforce), and an above average routine task content. In sum, this suggests that ICT increases the demand for highly skilled immigrants performing abstract tasks. The substitution of routine tasks, however, could potentially affect both middle and low skilled immigrants.

### 3.4 THE SKILL-BIASED EFFECT OF TECHNOLOGY ON LOCAL LABOUR MARKET OPPORTUNITIES

If immigrants sort themselves across destinations according to their (skill-related) economic opportunities, destinations with higher skill-premia should, ceteris paribus, attract more high skilled workers. In this section, we present suggestive evidence that ICT affected economic opportunities (in both wages and employment) differently across the skill-spectrum. We expect these skill-biased demand shifts to affect Swiss regions differently, depending on their historical specialisation. We start by analysing how the relative employment opportunities changed with routinisation potential. Panel A of Figure 1 depicts for each percentile of the skill distribution in 1990, the 20-year change in its employment share. Regions with an above median routine employment share in 1970 (grey diamonds)

are separately depicted from those below (black circles). The curves are remarkably similar in shape to those presented in [Autor and Dorn \(2013\)](#) and [Autor \(2015\)](#). Comparing the changes among new immigrants (Panel B) to those of all workers in (Panel A) reveals that employment changes among new immigrants follow a similar pattern as the change in the overall employment distribution. Yet, these changes are considerably more accentuated: the strong reduction in the middle as well as the strongest increase at the top of the skill distribution is 1.5 to 2 times as strong among new immigrants compared to the total workforce.



**Figure 1:** SMOOTHED CHANGES IN EMPLOYMENT SHARE 1990-2010 IN PERCENTILES OF THE 1990 WAGE DISTRIBUTION, FOR CZs ABOVE AND BELOW THE MEDIAN  $\widetilde{RSH}_{r1970}$

*Note:* The Figure plots the 20 year change in employment shares by skill percentile rank separated by above or below median of the historical routine share  $\widetilde{RSH}_{r1970}$ , Panel A all employment and Panel B only new immigrant workers. The construction of the Figures broadly follows [Autor and Dorn \(2013\)](#); see their Appendix for more details. Percentile ranks are constructed by pooling years 1991-1993, using real hourly mean log wages (in 2010 levels) within ISCO 2008 4-digit categories, weighted by survey weights and hours worked. If an occupation contributes to more than one percentile rank we allocate them based on their fraction of the occupation that maps into this percentile; we then simply calculate the difference between 2010 and 1990 employment shares within these percentile cells.

*Source:* Swiss census 1970, SAKE 1991-1993 and 2009-2011, own calculations.

In both figures, the reduction in the middle-paying occupations is more pronounced in high routine areas. For immigrants, high routine areas also show a decrease in employment at the bottom of the wage distribution, which is not the case for the overall workforce. This might be explained by the fact that immigrants in the lowest skill groups were also employed in occupations with a high routine task content, as documented above. The increase at the top of the wage distribution, in contrast, is more pronounced in high routine areas both among new immigrants and natives. In sum, there is a polarisation across the skill spectrum, as measured by the occupations' mean wages in 1990. Compared to the US's experience ([Autor and Dorn, 2013](#)), employment increases at the lower tail appear to be less pronounced; among recent immigrants, however, there appears to be a stronger increases in low RSH areas.

Next, we evaluate whether changes in employment opportunities are paralleled by changes in the relative wages across skill groups. To this end, we investigate how workers' wages in different education groups evolved across local labour markets. Given the clustering of workers with heterogenous skills

**Table 4:** RSH ON SKILL COMPOSITION: 2SLS

Dependent variable: Differences in residual wages estimated in stacked decadal differences				
	Wages		Log wages	
	(1)	(2)	(3)	(4)
<i>Panel a: High/Middle skilled</i>				
$\widetilde{RSH}_{r1970}$	10.112 (4.919)	10.996 (5.042)	0.187 (0.078)	0.254 (0.085)
<i>Panel b: Middle/Low skilled</i>				
$\widetilde{RSH}_{r1970}$	2.232 (1.958)	-4.362 (2.126)	0.063 (0.064)	-0.128 (0.073)
$N$	210	210	210	210
Covariates		✓		✓

*Notes:* Regressions include 2 decades across 105 CZ (1 is missing, relative to the main results). Standard errors in parentheses are clustered by CZ. Regressions include fixed effects for cantons, decades, and ams regions.  $\Delta(w_{rt}^j - w_{rt}^{j-1}) = \alpha_{cat} + \beta \widetilde{RSH}_{r1970} + \varepsilon_{crt}$ , where the dependent variable is the change in difference of the average wage (in absolute levels or logs) of individuals with education level  $j$  and  $j-1$ , e.g. highly and middle educated workers, over decade  $t$  in commuting zone  $r$  and canton  $c$ .  $\widetilde{RSH}_{r1970}$  is the commuting zone's 1970 specialisation in routine task employment as in equation (6). Covariates include offshoring potential and share of local employment in manufacturing, and whether the city has a University, which are the core variables used in the subsequent analysis and discussed in the next Section.

*Source:* Swiss census 1970, 1990-2010, SESS 1994-2010, own calculations.

in occupations with different task content (cf. Table 3), we expect the wage premium to increase between workers with high relative to middle education levels. Table 4 presents the results of a 2SLS regression testing this hypothesis, analogous to the (first stage) estimation of our main specification, cf. eq (5). The dependent variable is the change in the wage difference between highly and middle educated workers (Panel A) or the difference between middle and low educated workers (Panel B).<sup>27</sup> The wage difference is calculated by each education group's average wage in levels and logs, pooling native and immigrant workers. Columns 1 and 3 report estimates with specifications including year and canton fixed effects only, whereas Columns 2 and 4 also include commuting zone characteristics (which we discuss in detail below). Note that our wage data is based on a relatively small self-reported survey; therefore, we interpret these results cautiously as suggestive evidence.

Keeping this limitation in mind, the estimates in Panel A indicate that ICT exposure indeed had a strong positive effect on returns to skill. The estimate in Column 2 (Column 4), for instance, indicates that a one percentage point higher routine share in 1970 significantly increased the average hourly wage difference between those groups by roughly 0.10 Swiss Francs (0.18 percent) in one decade.<sup>28</sup> Economically, this is a meaningful effect: the corresponding hourly wage difference grew by 1 Swiss Franc ( $0.1 \times 5(IQR) \times 2$  decades) on average more in CZs at the 75th percentile compared to a CZ at the 25th percentile of the initial routine share distribution between 1990 and 2010.<sup>29</sup> In contrast

<sup>27</sup>To avoid spurious effects from demographic trends, we purge wages from individual level demographic characteristics. We do this by obtaining the residuals from a regression of individual-level wages (in absolute levels or logs) on a rich set of demographic variables (dummies for gender, marital status, immigrant status and cubics in potential labour market experience) each year. These residuals represent wage measures cleaned from demographic effects, and we average them by education level, CZ, and year.

<sup>28</sup>Note that the,  $RSH_{rt}$  ranges from 0 to 1.

<sup>29</sup>FTE is 42.5 hours a week with 52 weeks this adds up to 2,210 Swiss Francs a year, which approximates to half a

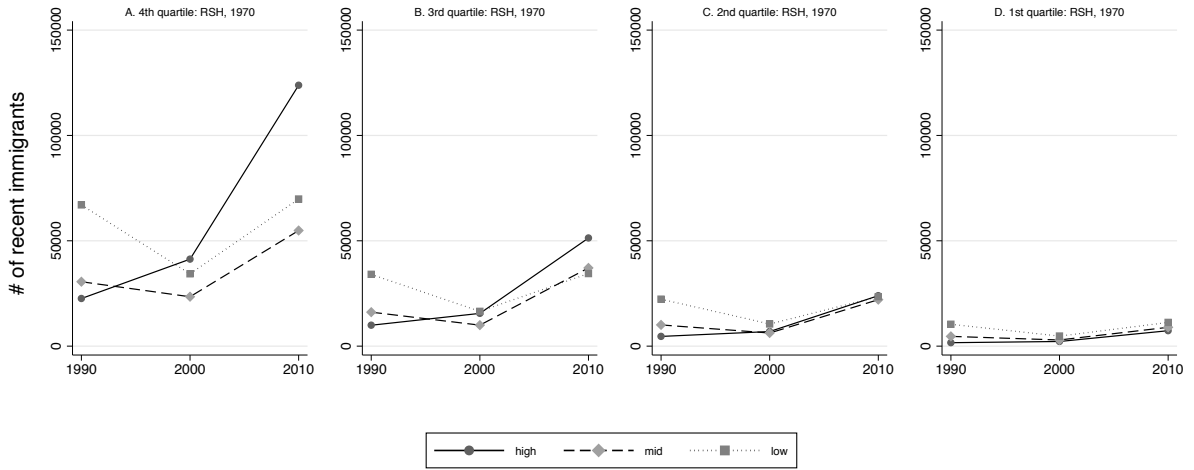
to the effect on the top end of the wage distribution, we do not find significant or even a negative association of the historical routinisation on the wage difference between middle and low educated workers.<sup>30</sup>

Taken together, these results suggest that in areas with higher ICT exposure both, earnings and employment opportunities for workers at the top of the skill distribution, generally increased relative to the middle. Consequently, we expect highly skilled immigrants to sort themselves into those regions, while observing a relative reduction in the inflow of middle skilled.

## 4 Results

### 4.1 SKILL-BIASED TECHNICAL CHANGE AND HIGHLY SKILLED MIGRATION

We start our analysis of the skill mix of recent immigrants by discussing their descriptive changes. Figure 2 shows the number of new immigrants by education group in each decade from 1990 to 2010. CZs are grouped into quartiles (Panel A to D) of the specialisation in routine occupations in 1970, our instrument.



**Figure 2:** TOTAL NUMBER OF RECENT MIGRANTS BY SKILL AND  $\widetilde{RSH}_{t-1970}$  QUANTILES

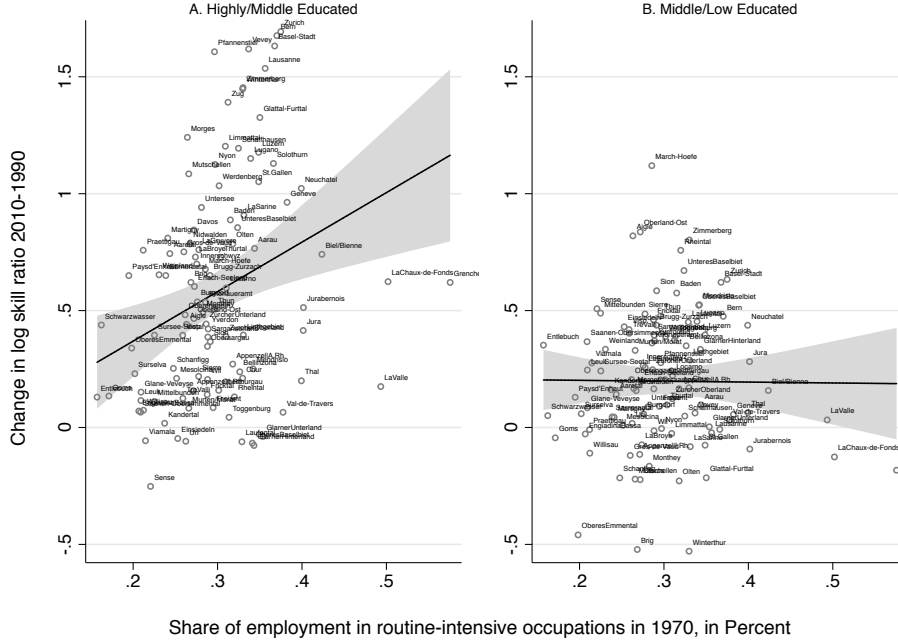
*Note:* Figure presents the total number of recent immigrants, by skill and by the quartile of routine share potential in the destination CZ 1970 ( $\widetilde{RSH}_{t-1970}$ ). Recent immigrants migrated 5 years prior to census evaluation.

*Source:* Swiss census 1970, 1990-2010, own calculations.

This figure illustrates the following facts. First, total immigration to Switzerland increased considerably from 1990 to 2010, and more than doubled over the two decades, from roughly 230 to 500 thousand (cf. also Table 2). Second, the evolution was very heterogenous across skill groups. In all regions, the number of highly skilled migrants was smaller than those of middle or low skilled in 1990. In later years, they grew substantially, overtaking the other two groups by 2010 in all but the first quartile. In contrast, both the inflow of new middle and low skilled migrants contracted between 1990 and 2000 and grew slower thereafter compared to highly skilled. Third, these trends are much more

median monthly income.

<sup>30</sup>When we exploit the full time dimension available in the SESS data, we find that the difference in the skill premium between high and low routine areas increased most strongly between 1994 and 2000 and stayed roughly constant thereafter. The evolution of the wage differential is presented in Figure A1 in the Appendix.



**Figure 3:** 20 YEAR CHANGE IN SKILL MIX OF RECENT IMMIGRANTS BY  $\widetilde{RSH}_{r,1970}$

*Note:* Figure presents scatter plot of 20 year change in log skill ratios plus one between high and middle (Panel A) and middle and low skilled (Panel B) over the  $\widetilde{RSH}_{r,1970}$  of 106 Swiss CZs, and its corresponding bivariate linear fit (and its 95% prediction confidence intervals). In Panel A, the intercept is -0.05 and slope 2.12 (0.69), and in B, the intercept is 0.21, and the slope coefficient is -0.04 (0.40).

*Source:* Swiss census 1970, 1990-2010, own calculations.

pronounced in CZs with a higher routine share in 1970. In these regions, the inflow of highly educated migrants grew progressively more between 1990 and 2000 while the inflow of less educated contracted strongly. Between 2000 and 2010, high-routine CZs experienced a substantial acceleration in the inflow of highly educated while the inflow of lower educated groups grew, but to a much smaller extent. In the lowest routine CZs, however, the lower two education groups grew slightly more strongly in the last decade. It is striking that our hypothesis is evident already in these descriptive plots where along the quartiles, there is an obvious increase in the growth of high skilled relative to middle skilled.<sup>31</sup>

Naturally, this heterogenous inflow of immigrants from different education groups led to a substantial change of the immigrants' skill mix in the long run (over the two decades) as illustrated in Figure 3. Each circle in this figure represents a CZ. Panel A presents the change in the log ratio of high to middle educated immigrants and Panel B the change of middle to low educated immigrants, respectively over the CZ's initial routine specialisation in 1970 (moving closer to our main specification). The Figure shows a strong positive change in the relative population weight of highly relative to middle educated immigrants (Panel A) but no change between middle and low educated immigrants (in Panel B).

Although these correlations strongly support the view that immigrants respond to changing economic opportunities, there might be unobserved factors which drive these patterns. Turning to our main results, Table 5 presents estimates of the coefficient of interest,  $\tau$ , from the regression as specified in eq. (5). In each regression, we instrument  $RSH_{rt}$  with its historical share  $\widetilde{RSH}_{r,1970}$  and include fixed effects at the level of cantons and source-by-decade. We use two-way clustered standard errors at

<sup>31</sup>Worth noting, the strong growth in the (overall) number of immigrants in the 2000s might reflect the implementation of the FMP policy, a point to which we return below.

**Table 5:** RSH EFFECT ON REGIONAL VARIATION IN THE SKILL COMPOSITION OF RECENT IMMIGRANTS: 2SLS

Dependent variable: Differences in log numbers and ratios of recent immigrants by skill group			
	2000-1990	2010-2000	Stacked
	(1)	(2)	(3)
Difference in log ratios			
<i>Panel a: High/Middle skilled</i>			
$RSH_{rt}$	1.397 (0.568)	3.195 (1.847)	2.232 (0.975)
<i>Panel b: Middle/Low skilled</i>			
$RSH_{rt}$	0.417 (0.503)	-1.397 (1.060)	-0.425 (0.520)
Difference in log numbers			
<i>Panel c: High skilled</i>			
$RSH_{rt}$	0.423 (0.723)	3.122 (1.814)	1.677 (1.043)
<i>Panel d: Middle skilled</i>			
$RSH_{rt}$	-0.974 (0.655)	-0.073 (0.915)	-0.556 (0.397)
<i>Panel e: Low skilled</i>			
$RSH_{rt}$	-1.391 (0.575)	1.324 (0.966)	-0.131 (0.564)
$N$	3,498	3,498	6,996

*Notes:* Regressions include 2 differenced time periods times 106 CZ times 33 source countries (one is a missing source category, we present robustness of dropping these in the Appendix Table A4). Standard errors in parentheses are clustered by CZ and origin country. Regressions include fixed effects for cantons, source countries, decades, and source times decades.

*Source:* Swiss census 1970, 1990-2010, own calculations.

the CZ and source country level as these might be correlated and are not nested (Cameron, Gelbach and Miller, 2011).<sup>32</sup> The regressions include 33 source countries in 106 CZ and 2 decadal differences (stacked), and are estimated separately for high-vs-middle (Panel A) and middle-vs-low skilled (Panel B). Panel C, D, and E show separate results for estimations with the change in the number of highly, middle, and low educated immigrants as dependent variables, respectively. The estimates in Panel A (and B) can be expressed as a linear combination of the estimated effects in Panel C and D (D and E, respectively).

The results confirm our previous conjectures. Column 1 in Panel A shows that a one percentage point higher routine share implied a 1.4 percent increase of highly skilled relative to middle-skilled immigrants between 1990 and 2010. This effect is statistically significant and even increases in the

<sup>32</sup>Note that the use of fixed effects and clustering standard errors is analogous to aggregate regressions that use the total number of high-skilled immigrants in region  $r$  at time  $t$  (aggregated over origin countries). Thus, the regressions are essentially based on 106 observations and 2 time periods. We later augment the regressions with origin country specific variables in which results will naturally differ (for a detailed discussion on using aggregate variables in non-aggregate models, see Lang and Gottschalk, 1996). To show consistent approaches across specifications, we use the full dataset throughout. The regressions are unweighted following the arguments in Solon, Haider and Wooldridge (2015); we assessed the impact of using source-country population weights, and it is reassuring that weighing makes little difference in our regressions (cf. Appendix Table A4, Column 5).



following decade to 3.2 percent (Column 2). Column 3 stacks the decadal changes in the skill ratios which produces a statistically significant average effect of 2.2 percent. The impact on the skill mix of immigrants is also economically meaningful: CZs with a 5 percentage points (roughly the interquartile range) higher initial routine specialisation experienced an approximately 11 percent larger inflow of immigrants with high relative to middle skilled. The estimates in Panel B, in contrast, show that ICT did not have a significant effect on the relative inflow of middle to low skilled.

Decomposing these relative effects in Panels C-E, reveals that, first, a higher initial routine share is associated with a larger inflow of highly educated immigrants throughout both periods, but particularly so between 2000 and 2010. Second, ICT reduced the inflow of middle-skilled immigrants in both periods. Thus, the strong positive effect we find in Panel A is in fact a combination of a positive effect on highly and a negative one on middle educated immigrants. Third, the disaggregation by decade shows that the positive effect in Panel A results from a greater negative effect on middle educated between 1990 and 2000 while the strong positive effect on highly educated dominates between 2000 and 2010. Fourth, ICT exposure lead to a significant reduction in the number of low skilled immigrants between 1990 and 2000 and had a positive, but insignificant, effect on their number between 2000 and 2010. The negative effect on low skilled in the first decade can be rationalised, as mentioned above, by the fact that a substantial part of this group was employed in routine intensive occupations in 1990 which were subsequently automated (cf., [Autor and Dorn, 2013](#)). In sum, the combined effects in Panel A and B are a result of mostly negative effects on the middle and low end of the skill distribution between 1990 and 2000. After 2000, ICT induced stronger growth at the poles of the skill distribution, particularly at the top end, hence suggesting strong polarisation by skill.

These results rely on variation in initial ICT exposure across CZs to identify the impact on newly arriving immigrants. Hence, a crucial exercise to establish strong internal validity of these results is to test several alternative hypotheses that might explain the skill mix changes across CZs. We do this in Table 6 by augmenting specification (5) with covariates considered important in the literature on bilateral migration and job polarisation.<sup>33</sup> In Column 1, we include an indicator for CZs in which a university was established prior to 1990.<sup>34</sup> Earlier literature suggested that opportunities for university education might provide an entry to a local labour market for highly skilled immigrant workers ([Grogger and Hanson, 2013](#); [Kato and Sparber, 2013](#)). Indeed, the estimated coefficient suggests that CZs with a university attract more highly relative to middle educated. Since most universities in Switzerland are located in larger cities, this effect could also be consistent with an agglomeration effect, i.e. individual workers enhancing each other's productivity (and wages) by working close to other skilled individuals as suggested by [Kerr et al. \(2016\)](#) and [Moretti \(2004\)](#).

In Column 2, we test the importance of ethnic networks in explaining differential skill-inflows. Immigrants' settlement decisions are strongly affected by pre-existing networks as they might increase chances of economic integration or provide information about the destination environment ([Card, 2001](#); [Patel and Vella, 2013](#)). In line with this prediction, our measure of networks, the share of immigrants from the respective source countries in 1970, has a positive impact on the number of middle skilled,

<sup>33</sup>By including dyadic covariates such as migrant networks the source dimension becomes important, consequently an aggregate regression would not yield the identical results, cf. Footnote 32.

<sup>34</sup>Prior to 1990, the following CZs contained a university: Basel, Bern, Fribourg, Geneva, Neuchâtel, Lausanne, St.Gallen, Zurich.



**Table 6:** RSH ON SKILL COMPOSITION, OTHER FACTORS: 2SLS

Dependent variable: Stacked decadal differences in log numbers and ratios by skill group									
	Population						Workers		
	(1)	(2)	(3)	(4)	(5)	(6)	All	Manu.	Service
Difference in log ratios									
<i>Panel a: High/Middle skilled</i>									
$RSH_{rt}$	1.612 (0.880)	2.275 (0.982)	1.840 (0.895)	2.103 (0.995)	3.953 (0.692)	2.824 (0.752)	3.077 (0.598)	1.032 (0.596)	2.781 (0.743)
University City <sub>r</sub>	0.329 (0.063)					0.174 (0.054)	0.138 (0.073)	0.117 (0.071)	0.171 (0.078)
Share $N_{rs1970}$		-2.023 (0.917)				-2.216 (1.004)	-0.758 (1.609)	1.645 (2.245)	0.287 (1.460)
Share $E_{rs1970}^3$			0.200 (0.062)			0.140 (0.057)	0.091 (0.039)	-0.012 (0.041)	0.087 (0.034)
Share $E_{rs1970}^2$			0.161 (0.071)			0.112 (0.066)	0.074 (0.046)	0.035 (0.045)	0.068 (0.037)
Offshoring potential <sub>rt</sub>				0.038 (0.034)		0.019 (0.032)	0.003 (0.035)	0.044 (0.024)	-0.017 (0.033)
Share manufacturing <sub>rt</sub>					-1.531 (0.422)	-1.076 (0.395)	-0.924 (0.384)	-0.049 (0.240)	-1.114 (0.380)
<i>Panel b: Middle/Low skilled</i>									
$RSH_{rt}$	-0.497 (0.513)	-0.458 (0.530)	-0.417 (0.552)	-0.268 (0.523)	0.421 (0.543)	0.932 (0.685)	0.552 (0.646)	0.392 (0.408)	0.379 (0.566)
University City <sub>r</sub>	0.038 (0.075)					-0.053 (0.088)	0.046 (0.085)	-0.018 (0.043)	0.087 (0.077)
Share $N_{rs1970}$		1.542 (0.872)				1.211 (0.771)	1.393 (0.956)	2.256 (0.726)	2.640 (0.779)
Share $E_{rs1970}^3$			-0.040 (0.063)			-0.067 (0.064)	-0.037 (0.040)	-0.015 (0.020)	-0.027 (0.042)
Share $E_{rs1970}^2$			0.033 (0.060)			0.010 (0.058)	-0.013 (0.049)	-0.052 (0.030)	0.004 (0.049)
Offshoring potential <sub>rt</sub>				-0.046 (0.035)		-0.053 (0.035)	-0.010 (0.023)	-0.008 (0.013)	-0.013 (0.023)
Share manufacturing <sub>rt</sub>					-0.753 (0.271)	-0.926 (0.338)	-0.459 (0.310)	-0.188 (0.205)	-0.364 (0.274)
Difference in log numbers									
<i>Panel c: High skilled</i>									
$RSH_{rt}$	1.082 (0.962)	1.571 (1.041)	1.385 (0.995)	1.574 (1.057)	3.683 (0.667)	2.799 (0.754)	1.983 (0.614)	0.270 (0.589)	1.666 (0.676)
<i>Panel d: Middle skilled</i>									
$RSH_{rt}$	-0.530 (0.396)	-0.704 (0.402)	-0.456 (0.405)	-0.529 (0.402)	-0.270 (0.445)	-0.026 (0.508)	-1.094 (0.461)	-0.762 (0.394)	-1.115 (0.481)
<i>Panel e: Low skilled</i>									
$RSH_{rt}$	-0.033 (0.530)	-0.246 (0.564)	-0.039 (0.561)	-0.261 (0.569)	-0.691 (0.646)	-0.957 (0.672)	-1.645 (0.766)	-1.154 (0.637)	-1.494 (0.634)
$N$	6,996	6,996	6,996	6,996	6,996	6,996	6,784	6,784	6,784

*Notes:* Standard errors in parentheses are clustered by CZ and origin country. Regressions include fixed effects for cantons, origin countries, decades, and origin times decade. All covariates correspond to beginning of period values. Column (1) includes, University city is an indicator for having a University in the CZ, (2) adds the share  $N_{rs1970}$  to capture the immigrant network by the share of immigrants from the same origin in CZ, (3) Share  $E_{rs1970}^j$  is the immigrant skill distribution in CZ, (4) offshoring potential<sub>rt</sub> of the local industry and (5) the industry share of manufacturing<sub>rt</sub>, both (4) and (5) missing values are set to zero and regressions include corresponding missing indicators, in the Appendix Table A4 we present robustness results concerning this specification. Column (6) uses all variables jointly. We classify workers in NACE Rev 1.1 codes 15-37 as “manufacturing” and codes 60-99 as “service”. More detailed effects by high and low manufacturing regions can be found in Appendix Table A6.

*Source:* Swiss census 1970, 1990-2010, own calculations.

which results in a negative effect relative to high skilled and a positive relative to low-skilled. In destinations with initially very low levels of highly educated, subsequent larger inflows could simply be due to mean reversion, as pointed out by [Michaels, Natraj and Van Reenen \(2014\)](#). Column 3 shows that the previous results are unaffected by controlling for the initial share of both highly and middle skilled by origin country in 1970 (implicitly this also accounts for the low skilled share).

Turning to associated local labour market hypotheses, task-offshoring is an important alternative explanation for long-run changes in the relative demand for skills ([Autor, Dorn and Hanson, 2013](#); [Dauth, Findeisen and Suedekum, 2014](#); [Goos, Manning and Salomons, 2014](#)). Specifically, firms might move routine-intensive tasks abroad to lower wage countries while focusing more on higher skilled tasks at home. In Column 4, we include a proxy from [Blinder and Krueger \(2013\)](#) on how susceptible local employment is to offshoring.<sup>35</sup> The estimates are very small and statistically insignificant for each education group.<sup>36</sup> Relatedly, we test the effect of the initial share of employment in manufacturing (cf. discussion in [Gould, 2015](#)), in Column 5. In fact, CZs with a higher manufacturing share experienced more inflow from lower education groups, i.e. more middle than highly skilled but also more low than middle skilled. Interestingly, controlling for manufacturing intensity increases the effect of ICT on both skill ratios. This is because regions with a high manufacturing share are also relatively routine intensive but experience a slower inflow of highly skilled immigrants. Thus, accounting for the heterogeneity across regions increases the overall effect. We will discuss the manufacturing sector’s role in more detail in the next section.

In sum, when we include the full set of explanatory variables in the model in Column 6, both coefficients of the routine share remain robust; the high-to-middle skill ratio increases considerably. This translates into an economically large effect. At the interquartile range of the initial ICT exposure, regions experienced roughly a 14 ( $5 \times 2.824$ ) percent larger inflow in the number of highly skilled than middle skilled immigrants. In contrast, the middle-to-low skilled evolution is positive but relatively small in magnitude and statistically insignificant.

## 4.2 HETEROGENEITY IN SORTING ACROSS SECTORS

Next, we examine whether the exposure to technology affected the skill mix of immigrants differently across sectors of employment (manufacturing versus non-manufacturing). [Autor, Dorn and Hanson \(2015\)](#), for instance, present evidence from the US highlighting that ICT, in the form of automation capital, reduced the routine employment of production workers in the manufacturing sector in the 1980s. In subsequent decades, the effect of ICT, this time in the form of computers, reduced routine (cognitive) employment in the service sector with accelerating intensity.

To investigate heterogeneous effects across sectors, Columns 7 to 9 in Table 6 present estimates from regressions analogous to those in Column 6, but for the subsample of workers. In contrast to population outcomes, estimates in this table are based only on employed immigrants (Column 7),

<sup>35</sup>[Blinder and Krueger \(2013\)](#) provide different measures of the exposure to offshoring, depending on individual worker level characteristics such as occupations or education levels. We use their measure for different education levels assessed by experts. We matched this measure to the education levels in the Swiss census and computed the average level of susceptibility to offshoring depending on the educational distribution of total employment at the beginning of a decade. The measure was further normalised to have mean zero and standard deviation one across CZs in 1980.

<sup>36</sup>We also tested other measures of the offshorability of ISCO-occupations taken from [Goos, Manning and Salomons \(2014\)](#) or as defined by [Autor and Dorn \(2013\)](#) for U.S. occupations. Including these controls did not affect our main estimates in any significant way, results not reported.

those employed in the manufacturing sector (Column 8), and in the service sector (Column 9). The estimates in Column 7 show a stronger effect of ICT exposure on the relative inflow of high to middle skilled new immigrant workers compared to the population estimates. This confirms that the economic opportunities also affect workers and not necessarily people outside of the workforce, which reinforces confidence in our proposed causal chain. This effect is composed of a slightly weaker effect on the inflow of high-skilled workers and a much stronger and significantly negative effect on middle and low skilled workers.<sup>37</sup> The split into the two different sectors of employment (Column 8 and 9) shows that the effects of ICT on manufacturing workers is dominated by the effect on those in the service sector. In the manufacturing sector, we only find a strong negative effect on middle skilled immigrants while the positive effect on highly skilled is more muted. Together, these produce much weaker and insignificant effects on the relative inflow of high-to-middle skilled immigrants in the manufacturing sector. The effect of ICT on the inflow of middle relative to low skilled immigrants is never significant. In the previous section, we found that the regional manufacturing share is negatively associated with the change in the high-to-middle skilled ratio. The result in Column 8 suggests that routinisation did not change the skill mix of immigrant employment in the manufacturing sector (and consequentially regions) as much as it did in the service sector (regions).

### 4.3 SOURCE COUNTRY HETEROGENEITY AND THE ROLE OF THE FREE MOVEMENT OF PERSONS POLICY

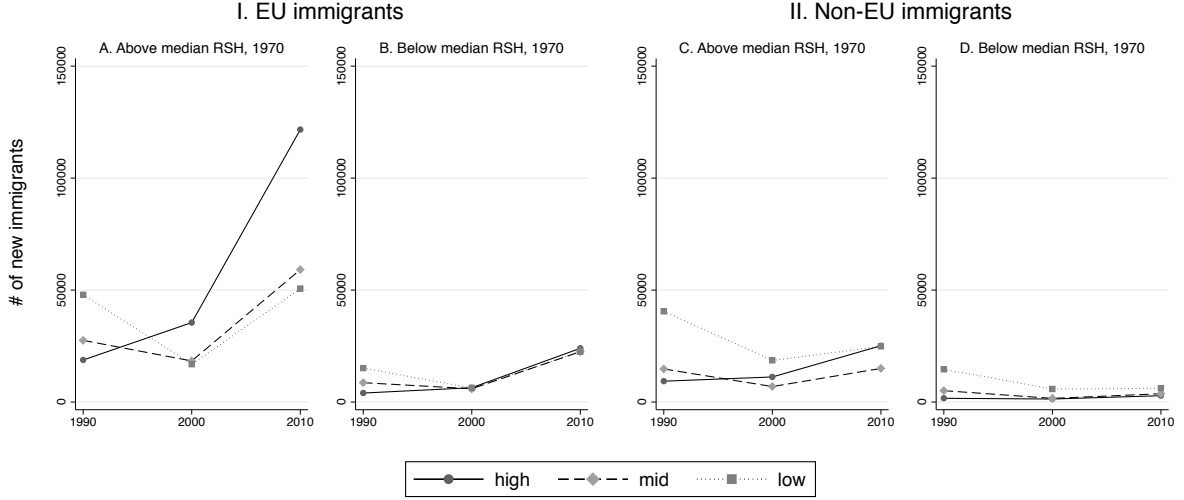
An important motivation of immigration policies is facilitating the entry of workers whose skills are scarce in the national labour market. Given the evidence presented above, a relevant question from a policy perspective is *whether* and *how* the response of immigrants to economic incentives changes when immigration restrictions are altered decisively. The Swiss experience between 1990 and 2010 is interesting in this regard as it allows evaluating the effects from the introduction of a free movement policy. As explained above, immigration restrictions for EU residents were progressively abolished after 2002, allowing them to move freely and adopt work unrestrictedly in Switzerland after 2007. In contrast, immigration from non-EU countries remained subject to quotas and further administrative hurdles. In this section, we aim to answer two questions: to which degree, if at all, did the lower cost of immigration for EU residents affect the skill mix of immigrants? And, did the openness allow immigrants to respond even more strongly to the skill-biased demand?

As a first step, Figure 4 takes a closer look at the effects of the policy by plotting the number of new immigrants from each skill group in each decade, separately for CZs above and below the median routine share in 1970, and separately for immigrants from EU countries (Panel A and B) and non-EU countries (Panel C and D). Roughly the same trends are evident as in Figure 2: i.e., CZs with a routine share above the median experience a stronger inflow of highly relative to middle educated immigrants. Yet, the number of immigrants from EU countries increased much stronger between 2000 and 2010 compared those from non-EU countries. Moreover, the larger inflow among EU immigrants is particularly pronounced in CZs with above median routine share. Thus, the Figure suggests that policy might have increased the inflow of immigrants from EU countries and likely induced stronger

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<sup>37</sup>In addition, in the Appendix we show (Table A6) show that this negative effect is most pronounced in the first decade (1990-2000) when Switzerland experienced only modest overall economic growth.

inflows to regions with higher skill-demand.



**Figure 4:** TOTAL NUMBER OF RECENT IMMIGRANTS BY SKILL BY  $\widetilde{RSH}_{t-1970}$  AREAS and source country

*Note:* Figure presents the total number of recent immigrants, by skill and by median split of routine share potential in the destination CZ 1970 ( $\widetilde{RSH}_{t-1970}$ ) for EU and non EU immigrants. We drop immigrants with missing source country information, from Poland, Romania, Hungary, and (former) Czechoslovakia that became EU member states within the time of analysis (results are not driven by this exclusion). Recent immigrants are migrated 5 years prior to census evaluation.

*Source:* Swiss census 1970, 1990-2010, own calculations.

Analysing the policy in our framework of eq. (3), the role of reducing entry restrictions would enter in the bilateral cost vector,  $\tilde{u}_{st}$ , as a reduction in migration costs for EU but not for immigrants from other origins. Empirically, we can evaluate this policy by including an indicator for the FMP in equation (5) as follows:

$$\Delta \tilde{y}_{rsct}^j = \tau RSH_{rt} + \gamma FMP_{st} + \Delta \tilde{u}_{st} \delta + \Delta \tilde{x}_{rst} \beta + \alpha_c + \alpha_s + \alpha_t + \Delta \varepsilon_{rsct}. \quad (7)$$

$FMP_{st}$  is an interaction of a dummy for immigrants from the EU and the decade between 2000 and 2010, i.e.  $1(s = EU) \times 1(t = 2000)$ . In this regression,  $\gamma$  measures whether the skill mix changes differently with the FMP policy for immigrants from the EU compared to immigrants from non-EU countries; irrespective of their destination within Switzerland. Since origin and time fixed effects absorb differential decade effects and origin country trends,  $\gamma$  is identified as the difference-in-difference effect where non-EU immigrants serve as a control group. The identification of  $\gamma$  hinges on the assumption of a parallel trend, i.e., that there are no changes affecting EU and non-EU immigration other than the policy. To support the validity of this assumption, we include a rich set of source-by-decade control variables, as it is a standard in the international migration literature (see, *inter alia*, Mayda, 2010; Ortega and Peri, 2013).<sup>38</sup> We are, however, hesitant to interpret this effect as causal, since the stable unit treatment value assumption (SUTVA) may be violated, e.g., if the larger inflow of EU citizens leads to a crowding-out (or crowding-in) of non-EU immigrants. Even without a fully causal interpretation, this is a very interesting and policy relevant comparison providing suggestive

<sup>38</sup>In particular, we include the following variables with origin-country decade variation: the beginning of period values of origin country's Gini-coefficient, its PolityIV score, GDP per capita, and an indicator of whether there was a conflict in the source country (increasing the share of asylum seekers) and a measure of skill supply in origin countries. The coefficient estimates of these control variable are reported in Appendix Table A7. The Table also presents how the estimated effects of the policy are similar if the control variables are taken in first-differences rather than beginning of period values.

evidence on how an immigration policy can moderate the response of immigrants to long-run labour demand shifts.

**Table 7:** RSH ON SKILL COMPOSITION, OTHER FACTORS: 2SLS

Dependent variable: Stacked decadal differences in log numbers and ratios by skill group					
	Difference in log ratios		Differences in log numbers		
	High/Mid	Mid/Low	High	Middle	Low
	(1)	(2)	(3)	(4)	(5)
<i>Panel a: Additive migration policy costs</i>					
$RSH_{rt}$	3.318 (0.768)	0.720 (0.761)	3.309 (0.807)	-0.009 (0.579)	-0.729 (0.748)
$FMP_{st}$	-0.065 (0.187)	0.016 (0.105)	0.392 (0.148)	0.499 (0.216)	0.309 (0.222)
<i>Panel b: Multiplicative migration policy costs</i>					
$RSH_{rt}$	2.974 (0.613)	0.776 (0.787)	2.365 (0.728)	-0.609 (0.784)	-1.385 (0.834)
$RSH_{rt} \cdot FMP_{st}$	1.372 (1.605)	-0.227 (1.285)	3.762 (2.004)	2.390 (1.564)	2.617 (1.851)
$N$	5,936	5,936	5,936	5,936	5,936
Covariates $_{rst}$	✓	✓	✓	✓	✓

*Notes:* Covariates include: all destination covariates from Table 6; since the free movement of people policy indicator is orthogonal to the source time decade fixed effects, we drop them and include an additional set of covariates to capture source country differences: 10 year-change in GINI coefficient, in real GDP per capita, polity4 score, and the corresponding change in labour supply of the group in focus, i.e. change in log number of high skilled in Column (3). We dropped the EU10 members which changed their EU status between 2000 and 2010; the results are robust so they are included in the policy group.

*Source:* Swiss census 1970, 1990-2010, own calculations.

Table 7 presents the results of the augmented regression specification, eq. (7). In Column 1 and 2, the dependent variable is the change in the log ratio of highly relative to middle and middle relative to low educated immigrants as before, respectively. Columns 3-5, show results when the outcome is the log difference in the number of new immigrants with a high, middle, and low education level, respectively. In Panel A, we allow the policy to have only a direct effect on immigration whereas Panel B, allows for an interaction with the skill-biased demand effect, as suggested by the differential evolution in Figure 4. Focusing first on the coefficient of  $RSH_{rt}$  in Panel A, we observe that the estimates presented here are of roughly the same magnitude as those in Table 6 across skill and skill ratio groups, assuring that the included origin country covariates capture most of the source-by-decade effects. The estimated coefficient of  $FMP_{st}$  is positive and large when each education group is considered separately. This suggests that policy increased the inflow of immigrants from EU countries in all three education groups by roughly 35 to 49 percent relative to those from non-EU countries. For the group of highly educated immigrants, the policy effect has a similar magnitude as a 10 percentage point higher routine share would produce (roughly 2 times the interquartile range in the 90s). These effects are economically large for each education group. Their similar size, however, explains why, in Column 1 and 2, the effect of the policy on the *relative* inflow of education groups is not statistically significant.

When we turn to the interaction effect of the policy with skill-biased demand in Panel B, we find that CZs with higher ICT exposure experienced larger inflows of immigrants from all education groups

as represented by the generally positive effects of the interaction term  $RSH_{rt} \cdot FMP_{st}$  in Column 3-5.<sup>39</sup> This interaction effect is only significant for the highly educated group. This indicates that regions with a higher ICT exposure were able to attract even more highly educated immigrants from EU countries after the free movement policy was implemented. This effect is also positive for two other education groups, although roughly 1 percentage point smaller and not statistically significant, which results in an insignificant interaction effect.

Taken together, these results suggest that, at the national level, the policy lead to a significantly larger inflow of immigrants in all education groups, potentially benefiting lower education groups slightly more. When inspecting heterogenous effects by region, we observe that the policy allowed regions with stronger skill-biased demand to attract even more highly skilled immigrants after immigration restrictions were abolished. Thus, the policy relaxed the constraint on access to skills and allowed immigrants to move to regions where their skills were most sought after. These findings align well with complementary evidence presented in [Ruffner and Siegenthaler \(2016\)](#) and [Beerli and Peri \(2017\)](#), who find that the FMP policy had a strong positive effect on firms in sectors which reportedly lacked qualified workers prior to the policy.

## 5 Conclusion

High-skilled immigration into OECD countries has been rising during recent decades, both in absolute and relative terms. In this paper, we provide evidence that the increasing inflow of high-skilled immigrants is a response to the profound impact of information and communication technology (ICT) which fuelled the demand for their skills.

In our analysis, we focus on newly arriving immigrants across 106 local labour markets in Switzerland between 1990 and 2010. In this period, the inflow of immigrants with a college education increased strongly, both in absolute terms and relative to other education groups. We leverage the fact that Swiss local labour markets were differentially exposed to ICT due to their specialisation in occupations with high routine task content in the pre-ICT area. We show that regions with a higher initial share of routine-intensive employment experienced considerably stronger wage and employment gains for highly educated workers in high-paying jobs relative to middle educated workers in intermediate wage ranks. The skill mix of new immigrants responded strongly to these ICT-induced changes in economic opportunities. In particular, we find that regions with higher ICT exposure experienced a stronger inflow of immigrants with a college education while the inflow of immigrants with an intermediate, secondary education was weaker between 1990 and 2010. Thus, ICT increased the relative number of highly to middle educated immigrants by roughly 14 percent, on average across decades, for a 5 percent increase in the routinisation potential. This effect is more pronounced in the second decade and concentrated in the service sector relative to the manufacturing sector.

Finally, we investigate whether and how the response of immigrants to economic conditions changed when Switzerland implemented a free movement policy that gradually abolished all immigration restrictions for EU residents after 2002. We find that the policy had a considerable effect on the total inflow of immigrants from EU countries (relative to those from other countries) but did not affect the

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<sup>39</sup>Note that we instrument this interaction term with our instrument, as in equation (6), interacted with the policy indicator.

relative size of different skill groups. Interestingly, however, and in contrast to this global effect of the policy, we find that areas with strong demand for skills induced by ICT benefited specifically from the policy by attracting even larger inflows of highly educated immigrants.



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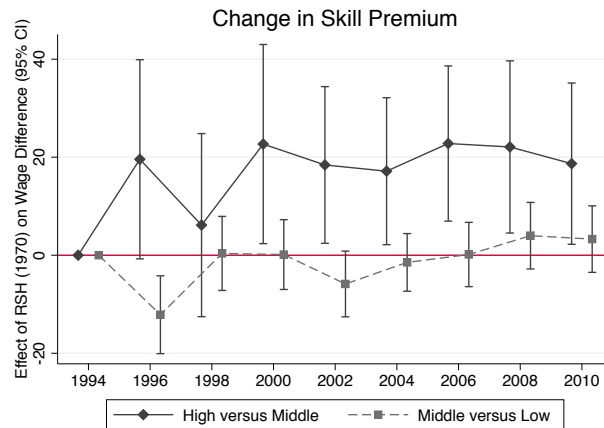
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# Appendix to The supply of foreign talent: How skill-biased technology drives the skill mix of immigrants

## Evidence from Switzerland 1990-2010

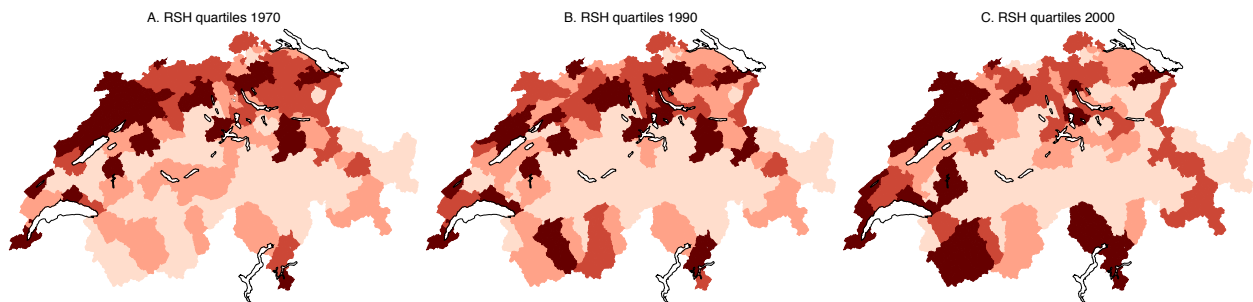
### A Additional and robustness results



**Figure A1:** EFFECT EVOLUTION OF  $\widetilde{RSH}_{t1970}$  UPON EDUCATIONAL MEAN WAGE DIFFERENTIALS, 1994-2010

*Note:* Figure presents coefficient estimates and corresponding 95% confidence bands based on a regression analogues to Table 4, the wages are cleaned by gender, experience and experience squared and weighted by sampling weights and hours worked. Standard errors are clustered on the CZ level.

*Source:* Swiss census 1970, SESS 1994-2010 own calculations.



**Figure A2:** GEOGRAPHICAL DISTRIBUTION OF  $RSH$  QUANTILES BY DECADE

*Note:* Figure presents within decade RSH quartiles over the map of Switzerland, darker areas refer to higher quartiles.

*Source:* Swiss census 1970, 1990, 2000, Geocoding BFS, 2017.

**Table A1:** RSH DESCRIPTIVE STATISTICS

	mean	p25	p75	Standard deviation		
				all	between CZs	within CZ
$\widetilde{RSH}_{r1970}$	0.30	0.26	0.33	0.068	0.050	0.053
$RSH_{r1990}$	0.25	0.23	0.28	0.038	0.028	0.031
$RSH_{r2000}$	0.25	0.23	0.27	0.034	0.025	0.027

*Notes:* Number of commuting zones (CZ) N=106, unweighted average and sample statistics. of IV and beginning RSH measure. The mean number of CZ within cantons are 7.1 and standard deviation 3.7.

*Source:* Swiss census 1970, 1990-2010, own calculations.

**Table A2:** EDUCATION GROUP SHARES BY ORIGIN COUNTRY

		1990						Change 1990 - 2010					
Origin		Origin	Educ. group share			Educ. group ratio		Origin	Educ. group share			Educ. group ratio	
Country		share	<i>H</i>	<i>M</i>	<i>L</i>	<i>H/M</i>	<i>M/L</i>	share	<i>H</i>	<i>M</i>	<i>L</i>	<i>H/M</i>	<i>M/L</i>
1	Austria	0.023	0.20	0.62	0.18	0.32	3.53	-0.003	0.34	-0.26	-0.07	1.17	-0.09
2	Belgium	0.007	0.54	0.35	0.12	1.54	2.99	0.000	0.19	-0.19	-0.00	3.03	-1.60
3	Canada	0.006	0.50	0.34	0.16	1.46	2.13	0.001	0.26	-0.20	-0.06	3.81	-0.64
4	Chile	0.002	0.23	0.30	0.47	0.77	0.65	-0.000	0.23	-0.12	-0.11	1.75	-0.13
5	China	0.003	0.49	0.17	0.34	2.78	0.51	0.006	0.05	-0.02	-0.03	0.64	-0.01
6	Germany	0.085	0.40	0.49	0.10	0.82	4.74	0.183	0.13	-0.10	-0.03	0.53	0.72
7	Denmark	0.004	0.37	0.43	0.20	0.88	2.13	-0.001	0.38	-0.24	-0.14	3.10	1.07
8	Algeria	0.002	0.33	0.34	0.33	0.98	1.04	0.000	0.04	-0.09	0.05	0.51	-0.39
9	Spain	0.057	0.05	0.17	0.78	0.30	0.22	-0.034	0.45	0.01	-0.46	2.41	0.35
10	Finland	0.002	0.48	0.40	0.12	1.21	3.32	0.001	0.28	-0.22	-0.07	3.01	0.17
11	France	0.057	0.30	0.48	0.22	0.61	2.16	0.024	0.36	-0.29	-0.07	2.83	-0.88
12	Greece	0.003	0.37	0.27	0.37	1.36	0.74	0.002	0.40	-0.13	-0.27	4.19	0.68
13	Hungary	0.003	0.45	0.39	0.16	1.18	2.40	0.007	0.05	0.01	-0.06	0.07	1.62
14	Israel	0.002	0.43	0.34	0.23	1.28	1.49	-0.001	0.22	-0.13	-0.09	1.86	0.03
15	India	0.010	0.16	0.16	0.67	1.01	0.24	-0.002	0.69	-0.10	-0.60	12.60	0.56
16	Iran	0.004	0.22	0.31	0.47	0.70	0.67	-0.001	0.29	-0.05	-0.25	1.22	0.54
17	Italy	0.079	0.11	0.27	0.63	0.39	0.43	-0.013	0.33	0.03	-0.36	1.10	0.68
18	Japan	0.006	0.55	0.20	0.25	2.71	0.80	-0.002	0.25	-0.06	-0.19	2.91	1.40
19	Balkan countries	0.210	0.07	0.26	0.67	0.25	0.39	-0.131	0.05	0.08	-0.12	0.08	0.23
20	Lebanon	0.019	0.10	0.24	0.66	0.43	0.36	-0.017	0.36	-0.06	-0.29	2.22	0.11
21	Liechtenstein	0.002	0.17	0.62	0.21	0.28	3.03	-0.001	0.27	-0.33	0.06	1.22	-1.94
22	Netherlands	0.014	0.45	0.40	0.16	1.13	2.49	-0.003	0.31	-0.25	-0.06	4.14	-1.08
23	Poland	0.005	0.42	0.37	0.22	1.14	1.68	0.010	0.07	0.01	-0.08	0.18	0.97
24	Portugal	0.163	0.01	0.13	0.86	0.10	0.15	-0.050	0.07	-0.02	-0.05	0.63	-0.01
25	Romania	0.005	0.31	0.29	0.40	1.06	0.72	0.002	0.22	0.00	-0.23	0.75	0.95
26	Sweden	0.006	0.57	0.29	0.14	1.96	2.11	-0.001	0.16	-0.13	-0.03	2.65	-0.65
27	Tunesia	0.004	0.14	0.44	0.43	0.31	1.02	0.001	0.21	-0.21	-0.01	1.22	-0.48
28	Czech Rep.+Slovakia	0.003	0.42	0.42	0.16	0.99	2.65	0.012	-0.10	0.17	-0.06	-0.46	3.43
29	Turkey	0.073	0.03	0.14	0.83	0.24	0.17	-0.056	0.16	0.05	-0.21	0.76	0.14
30	United Kingdom	0.020	0.53	0.26	0.20	2.02	1.29	0.016	0.27	-0.15	-0.12	4.80	0.14
31	USA	0.024	0.67	0.19	0.15	3.53	1.30	-0.000	0.17	-0.09	-0.07	5.25	-0.00
32	Vietnam	0.001	0.04	0.18	0.78	0.23	0.23	0.000	0.27	0.13	-0.41	0.77	0.61
33	Missing	0.096	0.16	0.18	0.66	0.88	0.28	0.050	0.18	0.01	-0.19	0.86	0.13

Notes: Table presents descriptive origin share and within origin education shares, and corresponding 20-year changes by individual countries.

Source: Swiss census 1970, 1990-2010, own calculations.

**Table A3:** RSH ON SKILL COMPOSITION: FIRST STAGE

Dependent variable: Contemporaneous routine share			
	1990	2000	Stacked
	(1)	(2)	(3)
<i>Panel a: only fixed effects (corresponding to Table 5)</i>			
$\widetilde{RSH}_{r1970}$	0.486 (0.060)	0.421 (0.051)	0.454 (0.053)
F statistic	49.4	50.8	62.5
R <sup>2</sup>	0.697	0.665	0.645
<i>Panel b: with covariates (corresponding to Column 6, Table 6)</i>			
$\widetilde{RSH}_{r1970}$	0.489 (0.057)	0.390 (0.057)	0.409 (0.056)
F statistic	22.8	16.5	26.1
R <sup>2</sup>	0.786	0.711	0.698
<i>N</i>	106	106	212
Mean dependent varriable	0.254	0.251	0.253

*Notes:* Regressions include, 106 CZ and 2 time periods in Column (3). All regressions include fixed effects for cantons and decades. Standard errors in parentheses are clustered by CZ level.

*Source:* Swiss census 1970, 1990-2010, own calculations.

**Table A4: ROBUSTNESS TO TABLE 6**

Dependent variable: Stacked decadal differences in log numbers and ratios by skill group, robustness							
	2000-1990	2010-2000	OLS	Workers	Weighting	Missing Source	Zero migration flows
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Difference in log ratios							
<i>Panel a: High/Middle skilled</i>							
$RSH_{rt}$	1.490 (0.590)	4.903 (1.566)	2.446 (0.542)	3.077 (0.598)	4.318 (1.039)	3.003 (0.748)	1.401 (0.412)
University City <sub>r</sub>	0.013 (0.074)	0.239 (0.127)	0.193 (0.055)	0.138 (0.073)	0.070 (0.062)	0.184 (0.055)	0.192 (0.051)
Share $N_{rs1970}$	-0.664 (1.704)	-3.845 (2.997)	-2.098 (1.001)	-0.758 (1.609)	-3.644 (1.687)	-2.406 (1.006)	1.915 (1.386)
Share $E_{rs1970}^3$	0.125 (0.068)	0.143 (0.102)	0.146 (0.055)	0.091 (0.039)	0.153 (0.064)	0.132 (0.057)	-0.022 (0.032)
Share $E_{rs1970}^2$	0.069 (0.070)	0.140 (0.131)	0.118 (0.068)	0.074 (0.046)	0.197 (0.099)	0.105 (0.066)	0.023 (0.027)
Offshoring potential <sub>rt</sub>	0.045 (0.029)	0.135 (0.065)	0.021 (0.032)	0.003 (0.035)	0.011 (0.052)	0.014 (0.033)	0.034 (0.019)
Share manufacturing <sub>rt</sub>	-0.501 (0.315)	-2.227 (0.809)	-0.986 (0.344)	-0.924 (0.384)	-1.672 (0.478)	-1.084 (0.409)	-0.456 (0.166)
<i>Panel b: Middle/Low skilled</i>							
$RSH_{rt}$	1.419 (0.721)	-0.363 (1.361)	0.048 (0.526)	0.552 (0.646)	1.521 (1.068)	0.852 (0.711)	0.563 (0.326)
University City <sub>r</sub>	0.025 (0.092)	-0.080 (0.183)	-0.008 (0.082)	0.046 (0.085)	-0.050 (0.094)	-0.058 (0.091)	-0.003 (0.052)
Share $N_{rs1970}$	2.592 (1.169)	-0.045 (1.303)	1.487 (0.814)	1.393 (0.956)	0.565 (0.611)	1.370 (0.791)	3.296 (0.653)
Share $E_{rs1970}^3$	-0.080 (0.071)	-0.043 (0.130)	-0.053 (0.063)	-0.037 (0.040)	-0.148 (0.067)	-0.061 (0.064)	-0.020 (0.037)
Share $E_{rs1970}^2$	0.031 (0.055)	-0.001 (0.110)	0.024 (0.059)	-0.013 (0.049)	-0.065 (0.102)	0.015 (0.058)	0.001 (0.026)
Offshoring potential <sub>rt</sub>	-0.050 (0.028)	-0.071 (0.096)	-0.049 (0.035)	-0.010 (0.023)	-0.061 (0.059)	-0.051 (0.034)	-0.013 (0.017)
Share manufacturing <sub>rt</sub>	-0.680 (0.349)	-0.679 (0.619)	-0.715 (0.265)	-0.459 (0.310)	-1.691 (0.533)	-0.974 (0.346)	-0.258 (0.182)
Difference in log numbers							
<i>Panel c: High skilled</i>							
$RSH_{rt}$	1.470 (0.617)	3.955 (1.383)	1.781 (0.578)	1.983 (0.614)	4.445 (0.879)	2.852 (0.770)	1.823 (0.525)
<i>Panel d: Middle skilled</i>							
$RSH_{rt}$	-0.020 (0.801)	-0.947 (1.205)	-0.665 (0.490)	-1.094 (0.461)	0.127 (0.775)	-0.151 (0.517)	-0.070 (0.353)
<i>Panel e: Low skilled</i>							
$RSH_{rt}$	-1.439 (0.751)	-0.584 (1.205)	-0.713 (0.560)	-1.645 (0.766)	-1.394 (0.773)	-1.003 (0.694)	-0.448 (0.427)
<i>N</i>	3,498	3,498	6,996	6,784	6,996	6,996	6,784

*Notes:* Standard errors in parentheses are clustered by CZ and origin country. Regressions include fixed effects for cantons, origin countries, decades, and origin times decade. City is an indicator for Basel-Stadt, Bern, Genf, Lausanne, Zurich. Share of immigrant from the same origin in the 70s. Contemporaneous High skilled and low skilled education share  
*Source:* Swiss census 1970-2000, Strukturerhebung 2010-12, own calculations.

**Table A5:** SKILL-MIX OF NEW IMMIGRANTS AND ORIGIN COUNTRY POPULATION BY ORIGIN COUNTRY GROUP

country group	Education group share			Education group ratio	
	high	middle	low	high/middle	middle/low
<i>Panel a: New immigrants in Switzerland</i>					
<i>1990</i>					
EU	0.19	0.30	0.51	0.65	0.59
Non-EU	0.13	0.23	0.64	0.55	0.36
<i>Change 1990–2010</i>					
EU	0.29	-0.02	-0.27	1.06	0.61
Non-EU	0.23	0.01	-0.24	0.94	0.24
<i>Panel b. Origin country population of immigrants</i>					
<i>1990</i>					
EU	0.09	0.37	0.54	0.25	0.69
Non-EU	0.11	0.35	0.54	0.32	0.64
<i>Change 1990–2010</i>					
EU	0.07	0.24	-0.31	0.02	2.04
Non-EU	0.08	0.15	-0.23	0.06	0.97

*Notes:* Education group shares and ratios among new immigrants (Panel A) in Switzerland replicated from table 1. The education group shares and ratios in the origin country population (Panel B) is computed using mean education group shares in the origin country groups (EU and non-EU) [Barro and Lee \(2013\)](#) using the number of new immigrants per origin country in Switzerland as weights.

*Source:* Swiss census and [Barro and Lee \(2013\)](#), 1990-2010, own calculations.



**Table A6:** APPENDIX TO COLUMN 7-9 OF TABLE 6

Dependent variable: Differences in log numbers and ratios of recent immigrants by skill group and sector												
	2000-1990			2010-2000			High Manu. regions			Low Manu. regions		
	Workers	Manu.	Service	Workers	Manu.	Service	Workers	Manu.	Service	Workers	Manu.	Service
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Difference in log ratios												
<i>Panel a: High/Middle skilled</i>												
$RSH_{rt}$	2.613 (0.683)	1.061 (0.526)	2.405 (0.793)	3.648 (0.870)	1.449 (1.065)	3.097 (1.098)	1.829 (1.665)	1.848 (2.111)	0.958 (1.555)	3.336 (0.972)	1.749 (0.521)	2.613 (0.981)
<i>Panel b: Middle/Low skilled</i>												
$RSH_{rt}$	0.362 (0.622)	0.499 (0.308)	-0.199 (0.800)	0.299 (0.909)	-0.089 (0.275)	0.688 (0.654)	2.402 (1.130)	0.685 (1.373)	2.275 (1.159)	0.183 (0.899)	0.460 (0.506)	0.156 (0.830)
Difference in log numbers												
<i>Panel c: High skilled</i>												
$RSH_{rt}$	0.863 (0.758)	-0.286 (0.592)	0.318 (0.793)	2.793 (1.194)	0.713 (1.132)	2.708 (1.240)	2.353 (1.645)	1.934 (1.846)	1.424 (1.606)	2.023 (0.756)	1.193 (0.609)	1.422 (0.645)
<i>Panel d: Middle skilled</i>												
$RSH_{rt}$	-1.750 (0.730)	-1.348 (0.586)	-2.087 (0.854)	-0.855 (0.579)	-0.736 (0.480)	-0.389 (0.782)	0.525 (0.998)	0.086 (1.207)	0.467 (0.679)	-1.313 (0.958)	-0.556 (0.447)	-1.191 (0.876)
<i>Panel e: Low skilled</i>												
$RSH_{rt}$	-2.112 (0.745)	-1.847 (0.687)	-1.889 (0.794)	-1.154 (1.179)	-0.647 (0.714)	-1.078 (0.945)	-1.877 (1.350)	-0.599 (1.284)	-1.809 (1.302)	-1.496 (0.981)	-1.016 (0.489)	-1.347 (0.887)
$N$	3,392	3,392	3,392	3,392	3,392	3,392	3,392	3,392	3,392	3,392	3,392	3,392
Covariates	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

*Notes:* Standard errors in parentheses are clustered by CZ and origin country. Regressions include fixed effects for cantons, origin countries, decades, and origin times decade. City is an indicator for Basel-Stadt, Bern, Genf, Lausanne, Zurich. Share of immigrant from the same origin in the 70s. Contemporaneous High skilled and low-skilled education share. We have dropped the EU10 members which changed their EU status between 2000 and 2010.

*Source:* Swiss census 1970-2000, Strukturerhebung 2010-12, own calculations.

**Table A7:** APPENDIX TO TABLE 7

Dependent variable: Stacked decadal differences in log numbers and ratios by skill group					
	Difference in log ratios		Differences in log numbers		
	High/Mid	Mid/Low	High	Middle	Low
	(1)	(2)	(3)	(4)	(5)
<i>Panel a: Additive migration policy costs, covariates in decadal differences</i>					
$RSH_{rt}$	3.318 (0.768)	0.720 (0.761)	3.309 (0.807)	-0.009 (0.579)	-0.729 (0.748)
$FMP_{st}$	-0.065 (0.187)	0.016 (0.105)	0.392 (0.148)	0.499 (0.216)	0.309 (0.222)
$\Delta \text{ Gini}_{st}$	0.080 (1.231)	-1.392 (1.012)	0.018 (1.443)	-0.939 (2.002)	1.345 (1.995)
$\Delta \text{ GDP}_{st}$	-0.383 (3.166)	9.159 (4.961)	-1.880 (3.876)	-0.325 (5.703)	-11.688 (6.040)
$\Delta \text{ Polity4}_{st}$	-0.001 (0.010)	-0.013 (0.015)	-0.020 (0.008)	-0.013 (0.015)	-0.005 (0.016)
$\text{Conflict}_{st}$	0.537 (0.154)	0.017 (0.407)	-0.970 (0.230)	-1.325 (0.367)	-1.543 (0.198)
$\Delta \tilde{y}_{st}^j$	0.076 (0.313)	0.156 (0.323)	0.387 (0.191)	-0.828 (0.895)	-0.580 (0.211)
<i>Panel b: Additive migration policy costs, covariates in beginning of period levels</i>					
$RSH_{rt}$	3.318 (0.768)	0.720 (0.761)	3.309 (0.807)	-0.009 (0.579)	-0.729 (0.748)
$FMP_{st}$	-0.062 (0.184)	0.098 (0.098)	0.271 (0.149)	0.432 (0.296)	0.245 (0.283)
<i>Panel c: Multiplicative migration policy costs, covariates in decadal differences</i>					
$RSH_{rt} \text{ rsh}$	2.974 (0.613)	0.776 (0.787)	2.365 (0.728)	-0.609 (0.784)	-1.385 (0.834)
$RSH_{rt} \cdot FMP_{st}$	1.372 (1.605)	-0.227 (1.285)	3.762 (2.004)	2.390 (1.564)	2.617 (1.851)
$\Delta \text{ Gini}_{st}$	-21.943 (14.279)	2.675 (4.752)	-20.830 (15.467)	2.387 (1.924)	-1.342 (6.589)
$\Delta \text{ GDP}_{st}$	-34.967 (8.240)	-0.807 (7.781)	-25.352 (9.903)	9.044 (15.813)	12.428 (8.410)
$\Delta \text{ Polity4}_{st}$	0.416 (0.581)	-0.478 (0.212)	0.850 (0.601)	0.366 (0.339)	0.917 (0.282)
$\text{Conflict}_{st}$	-7.131 (7.510)	4.422 (2.791)	-13.230 (7.864)	-5.340 (2.636)	-10.428 (3.154)
$\Delta \tilde{y}_{st}^j$	-0.085 (0.391)	0.079 (0.265)	-0.113 (0.370)	-0.397 (4.049)	0.113 (0.344)
<i>Panel d: Multiplicative migration policy costs, covariates in beginning of period levels</i>					
$RSH_{rt}$	2.974 (0.613)	0.776 (0.787)	2.365 (0.728)	-0.609 (0.784)	-1.385 (0.834)
$RSH_{rt} \cdot FMP_{st}$	1.372 (1.605)	-0.227 (1.285)	3.762 (2.004)	2.390 (1.564)	2.617 (1.851)
$N$	5,936	5,936	5,936	5,936	5,936
Covariates	✓	✓	✓	✓	✓

*Notes:* Standard errors in parentheses are clustered by CZ and origin country. Regressions include fixed effects for cantons, origin countries, decades, and origin times decade. City is an indicator for Basel-Stadt, Bern, Genf, Lausanne, Zurich. Share of immigrant from the same origin in the 70s. Contemporaneous High skilled and low-skilled education share. We have dropped the EU10 members which changed their EU status between 2000 and 2010.

*Source:* Swiss census 1970, 1990-2010, own calculations.

## B Stylized model of migration decisions

Writing out the full model in eq. (1) we have

$$\begin{aligned}\ln N_{rst}^j &= v_{rt}^{j'}\tau + v_{rt}'\tau^1 + v_r^{j'}\tau^2 \\ &+ u_{st}^{j'}\delta + u_{st}'\delta^1 + u_s^{j'}\delta^2 \\ &+ x_{rst}^{j'}\beta + x_{rst}'\beta^1 + x_{rs}^{j'}\beta^2\end{aligned}$$

and differencing by the next skill level gives eq. (2), in more detail

$$\begin{aligned}\ln N_{rst}^j - \ln N_{rst}^{j-1} &= v_{rt}^{j'}\tau - v_{rt}^{j-1'}\tau + v_r^{j'}\tau^2 - v_r^{j-1'}\tau^2 \\ &+ u_{st}^{j'}\delta - u_{st}^{j-1'}\delta + u_s^{j'}\delta^2 - u_s^{j-1'}\delta^2 \\ &+ x_{rst}^{j'}\beta - x_{rst}^{j-1'}\beta + x_{rs}^{j'}\beta^2 - x_{rs}^{j-1'}\beta^2\end{aligned}$$

and taking out time differences

$$\begin{aligned}\ln N_{rst+1}^j - \ln N_{rst+1}^{j-1} - (\ln N_{rst}^j - \ln N_{rst}^{j-1}) &= [(v_{rt+1}^{j'} - v_{rt+1}^{j-1'}) - (v_{rt}^{j'} - v_{rt}^{j-1'})]\tau \\ &+ [(v_{rt+1}^{j'} - v_{rt+1}^{j-1'}) - (v_{rt}^{j'} - v_{rt}^{j-1'})]\delta \\ &+ [(v_{rt+1}^{j'} - v_{rt+1}^{j-1'}) - (v_{rt}^{j'} - v_{rt}^{j-1'})]\beta \\ \Delta \ln \frac{N_{rst}^j}{N_{rst}^{j-1}} &= \Delta \tilde{v}_{rt}^{j'}\tau + \Delta \tilde{u}_{st}^{j'}\delta + \Delta \tilde{x}_{rst}^{j'}\beta\end{aligned}$$

which is our eq. (3).

## C More Details on Immigration Policies 1980-2010

Since the early 1970s, Swiss immigration policy was characterised by global quotas for different types of residency permits. At the end of each year, the federal government determined the number of new permits for different residency categories which would be allocated to Cantonal administrations proportional to population size. Cantonal administrations, in turn, would grant residency permits to firms which wanted to hire foreign workers if no equally qualified natives could be found for a given job (the so-called “priority requirement”).<sup>40</sup>

The first change to this policy came in 1991, when the federal government introduced new regulations requiring residency permits to be granted primarily to immigrants from EU17/EFTA countries while restricting immigration from other countries to ‘highly qualified’ individuals (Bundesrat, 1991).<sup>41</sup> Global quotas remained in place, however, until 2002.

After rejecting the proposal to join the European Economic Area in 1992 in national referendum, Switzerland and the EU signed a package of bilateral agreements on June 21, 1999, including the free movement policy for EU workers.<sup>42</sup> Accepting the free movement policy, one of the central pillars of the EU’s ‘acquis’, was a necessary concession of Switzerland to achieve liberalised trade with the EU. Details about the liberalization process were publicly announced by the federal administration (Bundesrat, 1999) and in 2000, the entire bilateral package was approved by a referendum in Switzerland in May 2000.

The enactment of the Free Movement of Persons Agreement (AFMP) with the European Union (EU) on June 1 2002 marked the second and most important change in the Swiss immigration policy. With the AFMP, the federal government introduced separate quotas for immigrant workers from EU17/EFTA and non-EU origin countries. After June 1 2004 the the priority requirement for natives was abolished and the border region was completely liberalised for cross-border workers from EU17/EFTA countries but not for resident immigrants.<sup>43</sup> From June 1 2007, workers from EU17/EFTA countries had unrestricted access to the Swiss labor market.

For Eastern European (EU8) countries, who jointed the EU in 2004, the AFMP was enacted on June 1, 2006, with the introduction of a separate quota. Prior to this date, they were part of the group of non-EU countries facing similar qualification restriction. On May 1st, 2011, quotas for EU8 countries were abolished granting free movement.<sup>44</sup>

Access was facilitated in a similar step-wise fashion for Romania and Bulgaria starting on June 1, 2009, by granting them a separate quota and the abolition of qualification restrictions. These quotas will be in place until mid 2016.

Access for immigrants from non-EU countries kept being subject to quotas and similar qualification restrictions as in the 1990s through our analysis period.(Bundesrat, 2002).<sup>45</sup> The quota was separated from European countries on June 1, 2002.

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<sup>40</sup>Exempted from the quota were newly immigrating family members of foreign residents and previous seasonal workers who spent at least five consecutive seasons working in Switzerland (Sheldon, 2007).

<sup>41</sup>‘High qualification’ mainly meant “managers, specialists and qualified professionals” but was deliberately defined broadly to include also investors, workers who specialised in the construction of certain facilities or tunnels or workers with special knowledge (Bundesrat, 1991, 2002). Third party countries included workers from eastern European countries as well as Bulgaria and Romania.

<sup>42</sup>The package of bilateral agreements included also agreements on the reduction of technical barriers to trade, the liberalisation of trade with agricultural good and public procurement, transport and the participation of Switzerland in the EU’s research framework programmes.

<sup>43</sup>EU17 countries include Germany, France, Italy, Luxembourg, Netherlands, Denmark, Ireland, United Kingdom, Greece, Portugal, Spain, Finland, Austria, Sweden, Cyprus and Malta. EFTA countries include Iceland, Norway and Liechtenstein. Cross-border workers are individuals commuting to work in Switzerland from one of the neighbouring countries. Prior to June 1 2004, these workers were also subject entry restrictions. As cross-border workers are not in our data set, we refer to (Beerli and Peri, 2017) for an extensive discussion.

<sup>44</sup>Until April 2014, the Federal Council had the opportunity to unilaterally re-introduce temporary quotas for immigrant workers from the EU, if immigration reached certain levels, through a so-called ‘Protection Valve’. Quotas were re-introduced between between April 2012 and 2014 for workers from EU8 countries and between April 2013 and 2014 for EU17/EFTA countries.

<sup>45</sup>Even though early reports from the federal council, (Bundesrat, 1991), are less precise and detailed about qualification requirements for non-EU immigrants than later reports, e.g. (Bundesrat, 2002), officials from the State Secretariat for Migration assured that these requirements were very similar.