



RESEARCH ARTICLE



# Successful due to STEM? Labour market returns to STEM qualifications among skilled immigrants in Germany

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## ABSTRACT



Against the growing demand for the STEM labour force, the study examines labour market returns to STEM qualifications among immigrants who arrived in Germany since the 1980s. Analysing the German microcensus data for years 2015 and 2016, we demonstrate that skilled immigrants with STEM qualifications largely attain better labour market outcomes in Germany compared to immigrants without STEM qualifications, thus narrowing the gap to their native-born counterparts. Male immigrants succeed in utilizing their STEM capital better than female immigrants, but all immigrants face difficulties in translating their STEM qualifications into STEM employment. Our analyses further focus on returns to various STEM qualifications, attesting that medical qualifications are especially beneficial for Germany's female immigrants. The analysis of heterogeneous effects of STEM qualifications across major migrant groups reveals that Eastern European male immigrants make the best of their STEM qualifications, whereas among women, STEM qualified from Turkey or MENA countries are the most successful. These and other findings are discussed both from the supply and demand sides of the labour market.


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**KEYWORDS** STEM qualification; immigrants; labour market; Germany

## Introduction

The changing demographic conditions of western industrialized societies and the goal to remain globally competitive and prosperous increasingly create demand for a scientifically-educated population and workforce, which is willing and able to engage in science, technology, engineering, and mathematics (STEM) (Lissitsa and Chachashvili-Bolotin 2019). In

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recent years, countries in the European Union have been experiencing recruitment difficulties in STEM-skilled labour, with shortages particularly pronounced for technological occupations (Engineering and ITC) and professionals (Caprile *et al.* 2015). Even though a larger share of students in Germany choose STEM fields compared to other OECD countries (OECD 2017), Germany is confronted with similar challenges. Increases in STEM labour demand are expected to outrun increases in enrolment (Erdmann and Koppel 2010). Many foreign students graduating in STEM fields – whereby STEM majors are particularly attractive for foreign students due to their less language-intensive curricula – do not transition to work in Germany (Erdmann and Koppel 2010; Oesingmann 2016). This occurs despite consistently higher employment rates among STEM academics – including those with immigrant background – compared to others in recent years (Anger *et al.* 2017, 26f.). The unemployment rate for STEM-skilled labour has indeed been very low and far below the total unemployment rate since the beginning of the 2000s in Germany. The situation is quite similar in other EU countries, including the Southern European countries, which are otherwise known for their recurring labour market difficulties.

Despite the significance of the topic, research on STEM participation and returns in Germany is rather scarce (Anger *et al.* 2017). Particularly little is known about the position of STEM-educated immigrants in this country (for notable exceptions see, Wrobel 2021). The current study fills this void by analysing economic returns to STEM qualification acquired abroad among recent immigrants to Germany. In particular, we examine whether STEM credentials could be considered a vehicle for immigrants' economic mobility and help Germany's immigrants of both genders narrow or even close the gap to the native-born majority on the labour market.

The study explicitly focuses on skilled immigrants arriving in Germany since the 1980s and sidesteps the *guest worker* migration of the 1950-1970s, which resulted in a significant increase in unskilled immigrants in Germany (Kogan 2011). Since the 1980s, migration to Germany has become more humanitarian in its nature, with immigrants arriving predominantly from Eastern European countries, the Middle East, and Asia. In this period, Germany has also accepted large numbers of ethnic German immigrants (*Aussiedler*), who arrived mainly from countries formerly constituting the Soviet Union, as well as Poland and Romania. Further, we cover immigrants from within the European Union (EU), who in recent years have been coming for the

most part from Eastern and Southern Europe. Finally, we also include holders of the Green Card, i.e. immigrants who arrived following the initiative introduced in 2000 to attract foreign specialists in information technologies. This along with other government initiatives indeed contributed to a meaningful increase in the numbers of highly-qualified specialists with migration background in Germany. Almost 38% of Green-card holders originated in countries of the Central and Eastern Europe, whereas about 28% arrived from India and Pakistan (bpb 2005).

This study resonates theoretically with the research focusing on the devaluation of the foreign credentials in the context of migration and the pathways of overcoming this on part of immigrants (Bratsberg and Ragan 2002; Buzdugan and Halli 2009; Kanas and van Tubergen 2009; Kogan 2012; Lancee and Bol 2017; Lo Iacono and Demireva 2018; Tibajev and Hellgren 2019; Zeng and Xie 2004). Several explanations mentioned by the authors of these papers, such as the lower signalling power of foreign credentials and risk aversion on part of employers who seem to consider these credentials not fully reliable, will also be discussed in the current study.

We proceed, firstly, with a summary of existing research on immigrants' STEM-related labour market outcomes from an international perspective and a presentation of the theoretical framework our study is built upon. This is followed by a description of the data source and methodological approach. We subsequently present our results, and conclude with a summary of main findings and discussion of the study's implications for migration and integration of STEM migrants in Germany.

### State-of-the-art research

Our knowledge about economic returns to STEM qualifications among minority ethnic groups – also differentiating by gender – primarily originates from North America. Boyd and Tian's (2018) findings based on the National Household Survey for Canada show that the bulk of immigrants have lower levels of labour market attainment compared to individuals born and raised in Canada and immigrants educated in the US, UK, and France, regardless of their STEM education. By merging the Canadian census to the National Household Survey, Picot and Hou (2018) analyse the education-occupation match among immigrant STEM workers on the Canadian labour market. They find a decline in this match for immigrants who entered Canada in the 2000s, irrespective of whether they hold a STEM or non-STEM qualification. Another key

finding of this study is a persisting gap in labour market outcomes for immigrant and native STEM-degree holders, which suggests that STEM-educated immigrants are unable to narrow the gap to the comparable native-born in Canada, a country that explicitly selects most of its immigrants based on their skills. A similar pattern is reported by Boyd and Tian (2017): First-generation immigrants with a STEM education who migrated as adults have worse labour market outcomes than individuals born in Canada, meaning that they have lower wages and are in general less likely to work in a STEM-related occupation. Boyd and Tian (2017) attribute these disadvantages partly to socio-demographic differences between immigrants and the native-born, immigrants' lower levels of language proficiency, and devaluation of educational degrees from abroad. All in all, results of the literature addressing labour market returns to STEM qualification among immigrants in Canada point to existing penalties among the disadvantaged groups with STEM qualifications. The bulk of foreign-born STEM degree holders cannot fully capitalize on their STEM qualifications on the labour market, particularly if these qualifications are acquired outside Canada or other developed countries.

Recent research from the United States regarding the chances of disadvantaged groups in STEM, such as women and racial or ethnic minorities, to close or at least narrow the gap to the benchmark majority population is also not entirely optimistic. By analysing the period between 2009 and 2011 in a pooled dataset from the Minnesota Population Centre, Wright *et al.* (2017) show that females holding a STEM degree are less likely to enter a matching STEM occupation compared to men. The authors also point to disadvantages particularly among Afro-Americans and Latinos (Wright *et al.* 2017). Drawing on the data from the American Community Survey from 2009 to 2018, VanHeuvelen and Quadlin (2021) ascertain that women holding a STEM degree are more similar to men without a STEM degree in terms of their labour market outcomes. This finding suggests that STEM qualifications certainly help females improve their labour market positioning but not to the same extent as STEM-educated men, resulting in pronounced gender inequalities. Quadlin *et al.*'s (2021) propensity score matching analyses of the data from the Education Longitudinal Study for the year 2002 further demonstrate that men benefit from prestigious STEM educations more than women do. Last but not least, Glass *et al.* (2013) analyses of the National Longitudinal Survey of Youth in the United

States reveal that females are at a higher risk of leaving STEM occupations compared to females in professional occupations in general.

It remains largely unknown whether the patterns found in the US-American and Canadian labour markets are similar to those observed in Europe. Based on the survey data collected in five European countries, namely Greece, Hungary, Italy, Sweden and the United Kingdom in 2018, Ricci *et al.* (2021) examine the labour market situation of highly skilled female immigrants holding a degree in a STEM field from the perspective of labour market intermediaries. The key finding of this study is that professional intermediaries assess the employability of migrant women in STEM as relatively low and strongly dependant on migrant women's language and non-cognitive skills, e.g. their resilience. The role of structural barriers, particularly in Southern Europe, has been further highlighted in this study.

In Germany, the topic of labour market returns to STEM qualifications has also received little attention in sociological literature, and the results are equivocal. Wrobel (2021) examines labour market trajectories of the German Green Card holders, who are largely ICT professionals coming from third countries to Germany, asserting a relatively high degree of integration success for this group. Among the factors contributing to this success the following were named: a larger size of the firm, employment in technically-oriented occupations and Central or Eastern European origin of immigrants. Anger *et al.* (2017, 26f) maintain that among the tertiary-educated with STEM in Germany – including those with immigrant background – employment rates are significantly higher compared with those without STEM qualifications. On the other hand, Grigoleit-Richter (2017) draws upon qualitative interviews with highly skilled immigrant women in the German city of Hamburg to report instances of discrimination, gender segregation, and credential devaluation.

Despite a high and rising demand for STEM-qualified labour, existing empirical studies largely reveal labour market difficulties among STEM-educated immigrants and lower returns to STEM qualifications among the foreign-born. What would be the reasons to expect that immigrants with STEM qualification could outperform those without STEM qualifications in the host country's labour market? Which theoretical arguments suggest that STEM-qualified immigrants could narrow or even close the gap to the socio-demographically comparable native-born?

## Theoretical framework

Our understanding of the immigrant labour market situation is based on a theoretical framework, which perceives immigrants' labour market allocation as a two-sided process involving two types of actors – newcomers and established members of the receiving society. What we empirically observe are the outcomes of this process, which represents the interplay of the receiving society's opportunity structures and immigrants' resources and preferences, which determine the choice of their opportunities (Kogan 2006, 2016).

On the side of the newcomers, individual resources particularly relevant for successful labour market integration are (1) human capital, e.g. education, training, labour market experience as well as cognitive and non-cognitive skills (Becker 1964), (2) cultural capital, e.g. language proficiency (Alba *et al.* 2002; Carliner 2000; Chiswick and Miller 2001; Van Tubergen and Kalmijn 2009; Esser 2006; Kosyakova *et al.* 2021), and (3) social capital, e.g. contacts within immigrants' ethnic community or within the host society (Portes and Rumbaut 2001; Portes 1998; Kanas *et al.* 2012; Kalter and Kogan 2014; Lancee 2012). Literature has repeatedly stressed that the resources immigrants bring with them are country-specific and not fully transferable into a host country (Chiswick 1978; Friedberg 2000; Kogan *et al.* 2011). The more dissimilar the structures and cultures of the sending and receiving societies, the less transferable individual resources for immigrants are (Kogan *et al.* 2011).

For some occupations, immigrants are expected to possess a set of resources, all of which are likely to be of limited transferability. For instance, practicing law in a foreign country is highly context-specific and requires perfectly transferable human capital, high host country language proficiency, and the availability of country-specific social capital. In contrast, practicing STEM occupations, particularly technical ones, presumes more universal and less host country-specific human capital. Therefore, STEM-qualified immigrants have better chances for economic integration from the beginning, i.e. immediately upon arrival, than immigrants with a similar level of education but no STEM qualification (Han 2016). Similarly, STEM occupations would probably require less host country language skills at the native-like level. Yet, the level of the required host-country language skills might vary depending on the communication requirements within the respective STEM occupations. Individuals engaged in medical fields might face higher communication requirements compared to IT specialists, for which non-English language requirements might be lower.

Recent research has emphasized the importance of the relative level of immigrants' education on their labour market outcomes in the destination country (Engzell and Ichou 2020; Schmidt *et al.* 2021; Spörlein and Kristen 2019). In this type of research, immigrants' educational level is compared to the distribution of educational qualification in the sending society. This implies that if the average level of education in a given sending society is high, the highly educated immigrants might not be particularly self-selected. The underlying idea of the self-selection argument is that immigrants are not a random sample from the population distribution of their origin countries, but rather a select group (Chiswick 1978). Such selection is particularly positive among economic immigrants, but among non-economic migrants the selection is not necessarily negative either (Borjas 1987, 1994+; Chiswick 1999). The (self-)selection argument overall implies that individuals migrating to other countries tend to belong to the most motivated, risk-taking and forwardly oriented portion of the sending society. In addition to skills-based resources, trait-based resources, such as self-esteem, optimism, self-efficacy, or resilience (Ryan *et al.* 2008, 7) are shown to play a considerable role for immigrant labour market success and be strongly correlated with immigrants' employment status and wages (Hahn *et al.* 2019; Laible and Brenzel 2021).

Another issue discussed in migration research is skill and credential transferability (Chiswick and Miller 2009; Friedberg 2000; Tibajev and Hellgren 2019). A key message of the pertinent research is that the lack of comparability of education, training systems, and labour markets between origin and destination countries might be responsible for the inadequate transferability of pre-migration education and training across the countries. Particularly in Germany, newcomers' qualifications are likely to only partially correspond to the standards applicable in this country. One reason for this is that educational contents and curricula are not entirely identical between sending countries and Germany (Lancee 2016; Lancee and Bol 2017), and this might be particularly true in the case of vocational training, which is organized in Germany somewhat differently than in other countries. The extent of comparability of skills might differ depending on the origin of educational credentials (and immigrants) and type of qualification. Practicing some occupations (e.g. medicine) is not possible without extensive retraining in the host country, which is likely to increase the match of immigrants' skills to employer requirements and improve returns to these skills (Kogan 2012).



Another potential mechanism of credential devaluation is the host country's employers' lack of information about foreign educational credentials and thus uncertainties regarding the value of immigrants' education, vocational education and training (VET), and underlying skills (Damelang *et al.* 2019; Damelang *et al.* 2020; Stumpf *et al.* 2020). Informational discrimination encompasses two major theoretical strands: Error and statistical discrimination. The error discrimination approach assumes that, due to lack of full information, false beliefs are inferred about the 'true' productivity of workers (e.g. England 1992, 60). Similarly, the statistical discrimination approach assumes that employers do not possess full information on the productivity of potential workers and therefore assign group characteristics (a group mean and/or a group variance) to individual workers that are perceived to belong to their group (Phelps 1972; Arrow 1972; Aigner and Cain 1977). Risk-averse employers also use information on the reliability of signals associated with immigrants' productivity (Hunkler 2014). The less reliable immigrants' education is for employers, the higher the chances for discriminatory tendencies among employers. Yet, research demonstrates that the extent of discrimination might be lower if occupations are high in demand and vacancies are difficult to fill (Baert *et al.* 2015).

The existence of employer discrimination in analyses of secondary data draws upon the assumption that immigrant origin exerts a residual 'effect' – labelled as ethnic penalties or ethnic premia – on various indicators of labour market performance net of other relevant observed factors (Heath and Cheung 2007; Gorodzeisky and Semyonov 2017). A well-known problem with this approach of detecting discrimination is omitted variable bias (Blank *et al.* 2004), as many datasets, including the one used for the current study, do not contain a full set of factors relevant to account for immigrants' labour market performance, such as individual non-cognitive skills, motivation, language proficiency, or the composition of immigrants' social networks.

The following analyses will concentrate on the ascertainment of average, STEM-field specific and origin-specific returns to STEM qualifications among immigrant groups, which dominated the migrant flow to Germany since 1980, sidestepping the explanations to the origin-group differences (for such discussions see Kogan [2011]; Kalter and Granato [2007]). Building on the arguments from the supply side (e.g. human capital theory) and the demand side (e.g. discrimination theories), we expect that compared to non-STEM-qualified immigrants, STEM-qualified immigrants are more likely to narrow the gap to the socio-



demographically comparable majority native-born Germans on a range of labour market indicators (*Hypothesis 1*).

To the extent immigrants to Germany (1) differ in their selectivity in terms of the STEM-related human capital and the transferability of their skills and qualifications and (2) due to the variation in the signalling value and reliability of STEM credentials and skills for the German employers, we expect variation in returns to STEM qualification *across immigrant groups* (*Hypothesis 2*).

To the extent that (1) some STEM skills are more transferable on the German labour market than others and (2) employers perceive them as more reliable and in demand, we expect variation in returns *across STEM qualifications* (*Hypothesis 3*).

## Data and methods

For our analyses we draw on the data from the German microcensus for the years 2015 and 2016 (RDC of the Federal Statistical Office and Statistical Offices of the Federal States).<sup>1</sup> The German microcensus is an annual survey of 1 percent of all households residing in Germany in a respective year. The German microcensus is also a rotating panel with each household participating in the survey every four years. This feature of the survey and the fact that the sampling frame was renewed in the year 2016 resulted in the selection of the most recent microcensus years with no overlaps of the surveyed respondents.<sup>2</sup> The mandatory character of the microcensus ensures its representativeness for the whole population of German residents. We analyse the Microcensus Scientific Use File, which is an anonymized 70 percent subsample of the original microcensus. This data source is appropriate for the aims of the analyses due to the availability of the detailed information on

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<sup>1</sup>The microcensus data available as Scientific Use Files can be ordered by scholars from the research data centers of the Federal Statistical Office and Statistical Offices of the Federal States for a provision fee. It should be noted that Scientific Use Files can only be ordered by independent Germany-based research institutions. Researchers abroad have the possibility to work with the data at the research data centers of the Federal Statistical Office and Statistical Offices of the Federal States after fulfilling a number of obligatory conditions, including commitment to strict data protection rules. The microcensus data usage is limited to the designated scholars and specified projects. For more information, see: <https://www.forschungsdatenzentrum.de/en/terms-use>.

<sup>2</sup>The microcensus data for year 2011 cannot be used for the current analyses as they contain a somewhat less detailed classification of occupations (3-digit ISCO number instead of 4-digit ISCO number). This would not allow researchers to unambiguously separate nursing and medical services (which are officially not considered STEM fields/occupations) from other medical professions, like human medicine (which are officially considered STEM fields/occupations). The 2007 microcensus data could not be used either, as they do not allow singling out Germans without migration background.

education, fields of study or training, and various labour market outcomes, as well as sufficient sample sizes to explore the variation across immigrant groups. This makes the microcensus a suitable dataset to answer our research questions, despite the apparent lack of rich information to address the potential explanatory mechanisms.

The focus on labour market indicators factored in selecting the study participants, who are individuals with and without migration experience of working age (25-65 years old). In this study, we juxtapose immigrants and the native-born. Native-born are those respondents who were born in Germany and who do not have the so-called migration background, meaning that their parents were not migrants either. Immigrants in our study are defined as individuals, who arrived in Germany since 1980 being at least 25 years old upon arrival. With this age restriction we select individuals, who were not only born abroad, but also completed their education in a different country and most probably arrived independent of their parents. As a consequence neither immigrants who arrived in Germany being younger than 25 or descendants of immigrants are included in our analyses. Information on the origin country of respondents' parents contains a high number of missing values, which prevents us from including the so-called second-generation immigrants as a comparison group in the analysis.

The German microcensus contains information on immigrants' country of birth, which enables a finer differentiation of immigrant groups, which is necessary for testing the second hypothesis. We clustered immigrants' countries of origin into the meaningful groups according to the countries' geo-political proximity and comparable patterns of immigrants' integration. Another criterion for the chosen classification was sufficient sample sizes of each immigrant group. The analyses differentiate between immigrants from (1) Northern, Western Europe and Southern Europe, as well as Americas, (2) Central and Eastern Europe, (3) Turkey, Middle East, North Africa and Central Asia, (4) East, South, and South-East Asia, (5) Other countries. The regression tables do not report coefficients for the latter category, i.e. other countries as well as for missing or unclassifiable origins, due to the group's heterogeneous origins and relatively small number of cases, but the cases of individuals classified under these categories are included into the analyses.

A central independent variable in our analysis is whether a respondent is educated or trained in a STEM field or not. We define STEM-qualified as individuals who have received educational training in the fields of

Science, Technology, Engineering, Mathematics, or Medicine. For the analyses testing the first hypothesis, we created a dummy variable differentiating between the STEM education or training vs. non-STEM qualification, whereas for the analyses testing the third hypothesis, we contrasted individuals trained in science, technology, engineering, and mathematics vs. those trained in medicine vs. those with non-STEM qualification. Our classification is based on the STEM classification of STEM fields from the German Federal Agency for Work (*Bundesagentur für Arbeit*) (2017). For more information on coding of study fields, see Table A1 and A2 in the appendix.

For the analyses of the returns to STEM qualifications, we created an interaction term between the dummy variables pertaining to the immigrant status (for Hypothesis 1) or the immigrant origin (for Hypothesis 2) and the dummy variable pertaining to the STEM field. For analyses of the differential returns to various STEM fields (Hypothesis 3) we created an interaction term between the dummy variable pertaining to the immigrant status and the dummy variables capturing categories of study/training fields.

Our study provides a multidimensional assessment of immigrants' labour market situation covering the following labour market outcomes: (1) unemployment propensity among those in the labour force, (2) probability of STEM employment, (3) occupational status of a job (captured by the [International Socioeconomic Index of Occupational Status, ISEI](#)) and (4) natural logarithm of monthly earnings. The unemployment propensity differentiates between those who are unemployed (= 1) and employed (= 0) and covers the labour force only. For estimating the propensity of employment in a STEM occupation, we differentiate between those employed in STEM occupations and those who are not. We classified occupations into STEM and non-STEM based on the information about the participants' occupation, which is measured on the ISCO-08 International Standard Classification of Occupations for micro-census years 2015, and 2016. We relied on the Classification of STEM occupations provided by the German Federal Agency for Work (2017). The assignment of occupations into the ISEI classification (Ganzeboom *et al.* 1992) was based on the routine provided by Schimpl-Neimanns (2004).

In the analyses we control for a number of variables, likely to account for the differences in the labour market outcomes among the origin groups. The educational level was categorized according to the CASMIN-classification (Granato 2000), differentiating between (1)

compulsory education or below (*Hauptschule* at most), (2) compulsory education (*Hauptschule*) and VET, (3) secondary intermediate level (*Realschule*), (4) secondary intermediate level (*Realschule*) and VET, (5) full maturity (*Abitur*) certificate, (6) full maturity (*Abitur*) followed by VET, (7) lower-level, and (8) full tertiary education. Categories 2, 4, 6, 7 and 8 of the variable pertaining to the educational level entered the multivariate analyses, as such analyses focus on individuals with completed vocational education or training (VET). We controlled for age and age-squared, and included a dummy variable pertaining to the marital status of individuals, differentiating between married individuals (= 1) and others (= 0). We further included a dummy variable differentiating between the person with (= 1) and without German citizenship (= 0). In the earnings equations, we additionally controlled for hours of work and industrial sector, coded in three sectors (agriculture, industry and services). Further, we differentiate between public and private sector jobs. All models included years and federal state fixed effects to account for the temporal and regional variation in the labour market conditions. For the descriptive information on all variables included into the modeling see Table A3 in the Appendix.

To ease the interpretation of the interaction terms we estimate linear probability or OLS models for all dependent variables, but also provide estimates of the corresponding binomial logistic regressions in the Appendix (see Tables A4, A5, A7, A8). For the outcomes STEM employment, ISEI, and earnings, we run the Heckman selection model to account for selection into the employment (Heckman 1979). A variable capturing the number of children in the family is included in the selection equation of the Heckman model, but not in the outcome equation (see full set of regression coefficients in Tables A6 and A9). All analyses are carried out separately by gender to account for different mechanisms of labour market allocation across gender. A replication package to the analyses can be found under <https://osf.io/rmd5b>.

## Patterns of STEM representation among immigrants and natives in Germany

In order to understand whether immigrants in Germany benefit from their STEM qualifications on the labour market we first explore what qualifications these immigrants bring with them. To this end, Table 1 presents two pieces of information. First, for the native-born and immigrants arriving since the 1980s separated by gender, we show the



**Table 1.** Distribution of education and STEM qualifications among native-born Germans and immigrants arriving since the 1980s, in percent.

	Natives				Immigrants			
	Men		Women		Men		Women	
	Distribution by level of education	Proportion STEM within the level	Distribution by level of education	Proportion STEM within the level	Distribution by level of education	Proportion STEM within the level	Distribution by level of education	Proportion STEM within the level
Compulsory education or below (at most <i>Hauptschule</i> )	5.04		7.07		23.22		26.59	
Compulsory education ( <i>Hauptschule</i> ) + VET	23.44	69.41	16.71	6.50	20.27	66.54	12.88	11.23
Secondary intermediate level ( <i>Realschule</i> )	1.22		2.12		5.25		5.92	
Secondary intermediate level ( <i>Realschule</i> ) + VET	22.61	57.4	28.13	9.82	14.09	64.56	13.83	12.42
Matriculation certificated ( <i>Abitur</i> )	2.58		1.91		4.91		5.63	
Matriculation ( <i>Abitur</i> ) + VET	18.80	61.24	20.86	13.49	7.73	64.23	8.93	16.25
Lower-level tertiary	2.51	44.08	3.43	8.19	3.57	65.32	3.38	24.22
Full tertiary	23.80	50.95	19.77	23.33	20.95	57.80	22.84	31.63
N	223,100		223,213		26,330		28,343	

Source: German microcensus, 2015, 2016;

Notes: Restricted to individuals 25–65 years old. Immigrants are those arriving since 1980 at age of at least 25 years old.

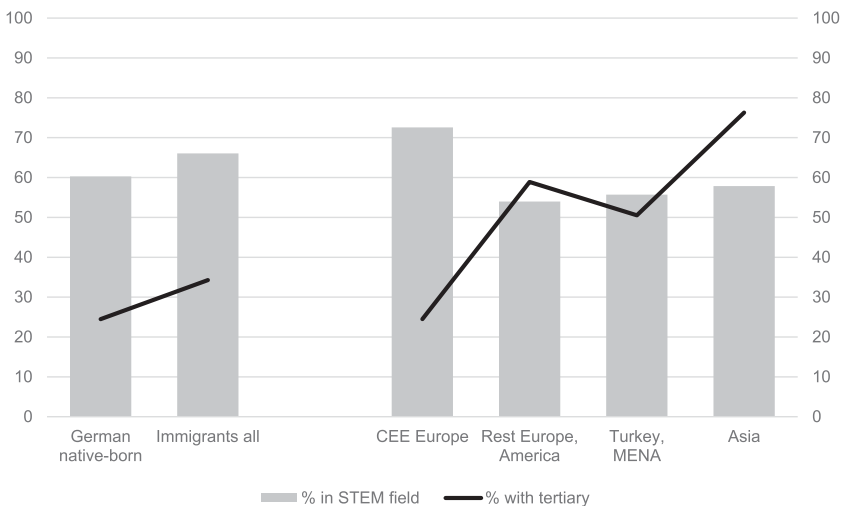
distribution of levels of education. Second, the proportion of individuals with STEM qualifications at each level of education can be found in this table. A first observation is the marked differences across natives and immigrants regarding the proportion of low-qualified individuals. Whereas in Germany far less than 10 percent of men and women have compulsory education only, this proportion oscillates between 23% for male and about 27% for female immigrants. Overall, immigrants are significantly less likely than native-born Germans to have vocational training. With regard to the share of the tertiary educated, there are no considerable differences between immigrants and the native-born among men. One noteworthy finding is that among women, the proportion of tertiary-educated is even somewhat higher in the immigrant population. The distribution of qualifications among immigrants arriving since the 1980s considerably deviates from the patterns observed among immigrants who came in the 1950–70s (Kalter and Granato 2007; Kogan 2011).

It is necessary to mention that the share of STEM qualified can only be calculated for individuals who possess vocational qualifications. Because far fewer immigrants possess such qualifications than the native-born, we exclude many more immigrants out of the analyses. Therefore, we should bear in mind for the conclusions that the immigrant sample of the qualified individuals is considerably more selective than among the native-born Germans, and our results probably pertain to the most skilled fraction of the immigrant population. From Table 1 we also notice that the distributions of STEM qualification among male respondents with and without migration background at the lower levels of education are rather similar. About 69% of the native-born and 66.5% of immigrant men with the compulsory education level possess STEM qualifications, whereas the corresponding figure for those with a matriculation certificate is 61% among the native-born and 64% among immigrants. At other levels of education, the proportion of STEM-qualified immigrants is higher than the respective proportion among the native-born. Particularly at the tertiary level, immigrants are more likely to possess STEM qualifications. The differences between the majority native-born and immigrant women in favour of the latter's higher representation in STEM are even more pronounced. Overall, as expected, many more men possess STEM qualification than women and this gender gap is observed both among immigrants and natives alike.

Figures 1 and 2 provide a more detailed information on the share of STEM-qualified individuals by migration status and immigrant origin, as well as the proportion of tertiary-educated among the STEM-qualified. It is noticeable in Figure 1 that among men, the proportion of STEM-qualified individuals is somewhat higher among immigrants (66%) than among the German native-born (60%). Differentiation by immigrant origin suggests the higher shares of STEM-qualified coming from the CEE countries (72.6%). For other male immigrants the shares are somewhat lower than among the majority native German men oscillating at about 55%.

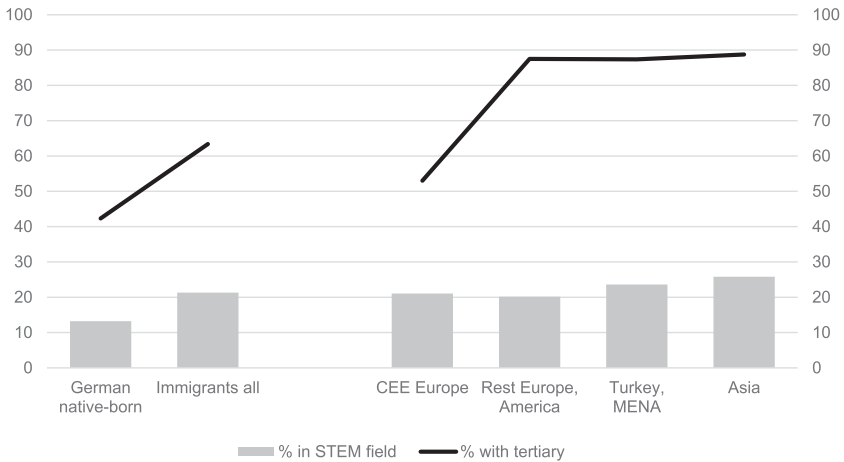
Another noteworthy pattern is that a higher proportion of STEM-qualified immigrants possesses tertiary degrees (34.3%) as compared to the German native-born men (24.5%). Differences across origin groups are also apparent, with about 25% CEE men being tertiary educated and about 77% of those originating in Asian countries being tertiary educated. Among other immigrant men the shares of tertiary educated among the STEM-qualified are all above 50%.

For women the picture is somewhat different (see Figure 2). Native-born German women have the lowest proportions of STEM-educated (13%) compared to female immigrants on average (21%) and compared to each single origin identified in the study. Particularly many STEM-qualified women arrive from Asian countries (26%). Another important



**Figure 1.** Male representation in STEM fields: immigrants and native-born Germans compared. Source: German microcensus, 2015, 2016. Notes: Restricted to individuals 25–65 years old. Immigrants are those arriving since 1980 at age of at least 25 years old.





**Figure 2.** Female representation in STEM fields: immigrants and native-born Germans compared. Source: German microcensus, 2015, 2016. Notes: Restricted to individuals 25–65 years old. Immigrants are those arriving since 1980 at age of at least 25 years old.

observation is that immigrant women with STEM qualifications are much more likely to possess them at the tertiary level than the native-born majority women, 63% vs. 42% respectively. Among women coming from Western and Southern Europe, America, Asia, and MENA countries, the proportion of tertiary-educated STEM degree holders are above 85%. The proportion is considerably lower among female immigrants from CEE countries (53%). This suggests that we have a rather selective sample of STEM-qualified women arriving in Germany from a wide range of countries but Eastern Europe, which might have an impact on origin-group specific patterns of labour market integration.

### Comparison of labour market outcomes between the STEM- and non-STEM-qualified immigrants and native-born Germans

In the following we present selected results from a series of multivariate regression analyses of various labour market outcomes comparing immigrants and native-born Germans with and without STEM qualification. Tables 2 and 3 contain three sets of models for men and women respectively. Model 1 in each table presents the unstandardized coefficients for the main effects of immigrants status and STEM qualification as well as the interaction between the two. In such models, the main effect of immigrant status captures the difference between immigrants and the native-

**Table 2.** Labour market outcomes of men with and without migration experience, selected results from the linear probability models and ordinary least square regressions with dependent variable as indicated on top of each column.

	Unemployment			STEM employment			ISEI			Log earnings		
	b		SE	b		SE	b		SE	b		SE
<b>Model 1</b>												
Immigrants (German native-born – ref.)	0.04	***	(0.00)	0.17	***	(0.01)	–16.00	***	(0.42)	–0.36	***	(0.02)
STEM qualification (non-STEM – ref.)	–0.00	*	(0.00)	0.51	***	(0.00)	–0.28	***	(0.08)	0.02	***	(0.00)
x immigrants	–0.00		(0.00)	–0.17	***	(0.01)	3.07	***	(0.35)	0.07	***	(0.02)
<b>Model 2</b>												
Origin (German native-born – ref.)												
CEE Europe	0.03	***	(0.00)	0.18	***	(0.01)	–16.48	***	(0.43)	–0.38	***	(0.02)
Rest Europa, America	–0.01		(0.01)	0.14	***	(0.02)	–4.23	***	(0.63)	–0.06		(0.03)
Turkey, MENA	0.11	***	(0.01)	0.22	***	(0.03)	–20.09	***	(0.87)	–0.46	***	(0.05)
Asia	0.02		(0.01)	0.15	***	(0.04)	–14.24	***	(1.33)	–0.37	***	(0.07)
STEM qualification (non-STEM – ref.)	–0.00	**	(0.00)	0.51	***	(0.00)	–0.31	***	(0.08)	0.02	***	(0.00)
x CEE Europe	–0.01	*	(0.00)	–0.20	***	(0.01)	3.13	***	(0.42)	0.08	***	(0.02)
x Rest Europa, America	0.02	*	(0.01)	–0.06	**	(0.02)	4.14	***	(0.71)	0.08	*	(0.04)
x Turkey, MENA	0.00		(0.01)	–0.21	***	(0.02)	8.36	***	(0.84)	0.24	***	(0.05)
x Asia	–0.00		(0.02)	–0.10	*	(0.05)	11.19	***	(1.61)	0.05		(0.09)
<b>Model 3</b>												
Immigrants (German native-born – ref.)	0.04	***	(0.01)	0.02		(0.03)	–9.71	***	(0.95)	–0.27	***	(0.05)
STEM technical field (STEM medical – ref.)	0.01	**	(0.00)	–0.13	***	(0.01)	–15.00	***	(0.32)	–0.33	***	(0.02)
x immigrants	–0.01		(0.01)	–0.02		(0.03)	–3.56	***	(0.94)	–0.02		(0.05)
Non-STEM field	0.01	***	(0.00)	–0.64	***	(0.01)	–14.20	***	(0.32)	–0.33	***	(0.02)
x immigrants	–0.00		(0.01)	0.15	***	(0.03)	–6.15	***	(0.95)	–0.09		(0.05)
N	187,638			181,419			181,419			176,448		

Source: German microcensus, 2015, 2016;

Notes: \*  $p < 0.05$ , \*\*  $p < 0.01$ , \*\*\*  $p < 0.001$ ; Restricted to individuals 25–65 years old. Immigrants are those arriving since 1980 at age of at least 25 years old.

**Table 3.** Labour market outcomes of women with and without migration experience, selected results from the linear probability models and ordinary least square regressions with dependent variable as indicated on top of each column.

	Unemployment			STEM employment			ISEI			Log earnings		
	b		SE	b		SE	b		SE	b		SE
<b>Model 1</b>												
Immigrants (German native-born – ref.)	0.03	***	(0.00)	0.02	***	(0.01)	–16.55	***	(1.01)	–0.44	***	(0.03)
STEM qualification	0.01	***	(0.00)	0.36	***	(0.00)	2.07	***	(0.32)	–0.00		(0.01)
x immigrants	0.00		(0.00)	–0.08	***	(0.01)	2.00		(1.12)	0.02		(0.04)
<b>Model 2</b>												
Origin (German native-born – ref.)												
CEE Europe	0.03	***	(0.00)	0.02	**	(0.01)	–16.61	***	(1.04)	–0.44	***	(0.03)
Rest Europa, America	0.02	***	(0.01)	0.02		(0.01)	–6.04	***	(1.84)	–0.27	**	(0.06)
Turkey, MENA	0.14	***	(0.01)	0.03		(0.03)	–25.60	***	(3.81)	–0.76	***	(0.12)
Asia	0.05	***	(0.01)	0.01		(0.02)	–19.02	***	(3.21)	–0.57	***	(0.10)
STEM qualification (non-STEM – ref.)	0.01	***	(0.00)	0.36	***	(0.00)	2.09	***	(0.35)	–0.00		(0.01)
x CEE Europe	0.00		(0.01)	–0.14	***	(0.01)	0.40		(1.44)	–0.05		(0.05)
x Rest Europa, America	–0.01		(0.01)	0.04	*	(0.02)	3.04		(2.85)	0.12		(0.09)
x Turkey, MENA	0.00		(0.02)	0.07	*	(0.04)	10.42	*	(4.87)	0.24		(0.16)
x Asia	0.04	*	(0.02)	0.04		(0.03)	7.82	***	(4.89)	0.28		(0.16)
<b>Model 3</b>												
Immigrants (German native-born – ref.)	0.01		(0.01)	0.17	***	(0.02)	–2.84		(2.45)	–0.22	***	(0.02)
STEM technical field (STEM medical – ref.)	0.02	***	(0.00)	–0.01		(0.00)	–8.24	***	(0.68)	–0.12	***	(0.02)
x immigrants	0.03	**	(0.01)	–0.29	***	(0.02)	–13.76	***	(2.59)	–0.48	***	(0.09)
Non-STEM field	0.01	**	(0.00)	–0.38	***	(0.00)	–8.07	***	(0.60)	–0.08	***	(0.02)
x immigrants	0.02	**	(0.01)	–0.15	***	(0.02)	–13.80	***	(2.38)	–0.42	***	(0.08)
N	168,279			163,237			163,237			159,916		

Source: German microcensus, 2015, 2016;

Notes: \*  $p < 0.05$ , \*\*  $p < 0.01$ , \*\*\*  $p < 0.001$ ; Restricted to individuals 25–65 years old. Immigrants are those arriving since 1980 at age of at least 25 years old.

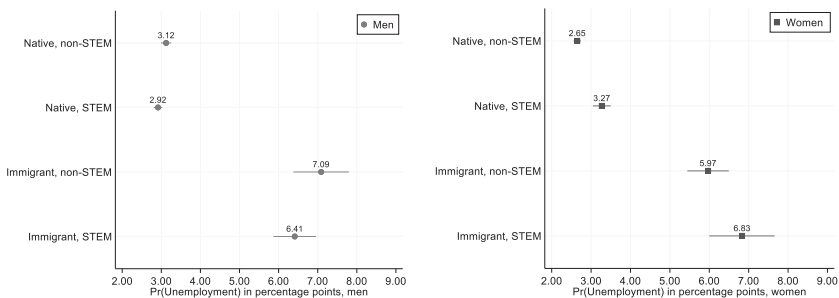
born in the respective outcomes for those without STEM qualifications. The main effect of the STEM qualification juxtaposes the outcomes for the STEM – and non-STEM – qualified among the native-born Germans. The interaction effect, on the other hand, documents a gap in returns to STEM qualifications for an average immigrant in comparison with the native-born German. Model 2 presents the heterogeneous effects of STEM qualifications across origin groups (i.e. interaction effects between immigrants' origins and the STEM qualification). Similarly to the Model 1 specification, with interaction effects included, the main effect of the STEM qualification pertains to the effect for the native-born group, whereas the interaction effects pertain to the difference in returns to STEM qualifications for each immigrant origin from the native-born Germans. Main effects of various origin groups document the differences between immigrants from the respective origins and the native-born Germans in the labour market outcomes. Model 3 estimates returns to STEM qualifications while differentiating between technical and medical fields for the native-born Germans (reflected in the main effects) and immigrants (reflected by the interaction effects). In Model 3 medical fields serves as a reference category, so that they are contrasted with STEM technical fields and non-STEM fields.

All three models take a broad set of control variables into account as indicated in the methodological section. The analyses of STEM employment, ISEL, and Log earnings contain the Heckman correction, i.e. they take into account the selectivity into employment among the analyzed groups (for the full set of coefficients refer to Table A4-A9 in the Appendix).

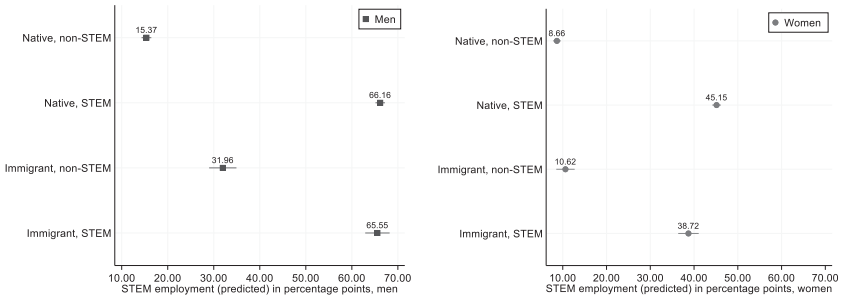
Results from Model 1 presented in [Table 2](#) suggest that an average male immigrant without a STEM qualification in Germany is more likely to be unemployed, employed in a STEM area, work in occupations of lower occupational status and earn less. Among the native-born German men, STEM qualifications tend to somewhat protect from unemployment, lead to STEM occupations, be associated with lower-status jobs, but higher earnings. Among male immigrants, STEM qualifications are associated with more favourable outcomes in terms higher-status jobs and earnings compared to the STEM-qualified native-born Germans. However, the premia from having STEM qualification in terms of STEM employment is much lower among immigrants than the native-born, whereas there are no differences between the two groups in unemployment propensity.

The patterns of labour market outcomes among immigrant women without STEM qualifications (see Model 1, Table 3) are largely in line with those observed for immigrant men. Yet, labour market outcomes of STEM qualified native-born German women differ from those of men: compared to non-STEM-qualified, STEM qualified German women are somewhat more likely to be unemployed as well as employed in jobs of higher occupational status. Further, there is no wage premia associated with STEM qualification among the native-born German women. Female immigrants with STEM qualifications do not differ from German women in their unemployment propensities, occupational status and earnings, but are less likely to be found in STEM jobs compared to their native-born counterparts.

In the following, we visualize the patterns of labour market outcomes for immigrants and natives, separately for men and women, by plotting predicted values for unemployment (Figure 3), STEM employment (Figure 4), ISEI (Figure 5), and wages (Figure 6). In line with the results of point estimates, native-born women and men have lower unemployment, but the unemployment patterns for STEM and non-STEM-qualified immigrants and native-born of each gender do not differ. Whereas the STEM-qualified men – either immigrants or the native-born – face lower unemployment, STEM-qualified women independent of their origin are confronted with more difficulties finding employment. Patterns of STEM employment presented in Figure 4 suggest smaller gaps in STEM employment between immigrants with and without STEM qualifications compared to those of natives. This occurs due to the higher levels of STEM employment among non-



**Figure 3.** Unemployment by gender, migration background and STEM field, adjusted predicted values in percentage points, results of the linear probability model. Source: German microcensus, 2015, 2016. Notes: Restricted to individuals 25–65 years old. Immigrants are those arriving since 1980 at age of at least 25 years old.

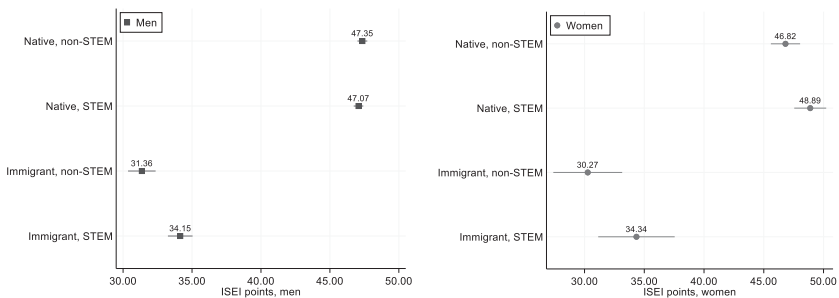


**Figure 4.** STEM employment by gender, migration background and STEM field, adjusted predicted values in percentage points, results of the linear probability model. Source: German microcensus, 2015, 2016. Notes: Restricted to individuals 25–65 years old. Immigrants are those arriving since 1980 at age of at least 25 years old.

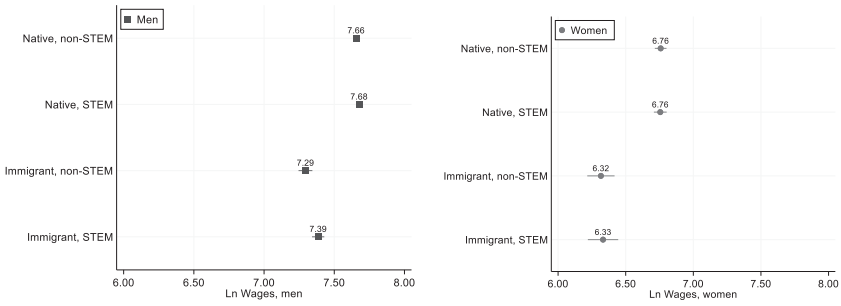
STEM-qualified immigrant men and lower levels of STEM employment among STEM-qualified female immigrants. With respect to the jobs’ occupational status, STEM qualifications bring considerably higher premia for both female and male immigrants than the native-born (see Figure 5). In terms of pecuniary returns to STEM qualifications, they seem to be higher for immigrant than native-born men (Figure 6). At the same time, STEM and non-STEM qualified women – immigrants and the native-born respectively – do not differ from one another.

### Heterogeneous returns to STEM qualifications

Results from Model 2 (Table 2) demonstrate that non-STEM qualified immigrants from Central and Eastern Europe, Turkey and MENA



**Figure 5.** ISEI by gender, migration background and STEM field, adjusted predicted values in ISEI score points, results of OLS regression. Source: German microcensus, 2011, 2015, 2016. Notes: Restricted to individuals 25–65 years old. Immigrants are those arriving since 1980 at age of at least 25 years old.



**Figure 6.** Wages (natural logarithm) by gender, migration background and STEM field, adjusted predicted values on a logarithmic wage scale, results of OLS regression. Source: German microcensus, 2015, 2016. Notes: Restricted to individuals 25–65 years old. Immigrants are those arriving since 1980 at age of at least 25 years old.

counties face significant employment difficulties. Yet, STEM-qualified male immigrants from CEE countries seem to be protected from unemployment more than their native-born counterparts. One surprising finding is that STEM-qualified immigrants from other European countries have larger difficulties finding employment than the native-born. The rest of the immigrants do not differ from the native-born Germans regarding the extent to which STEM qualifications protect them from unemployment.

In terms of the propensity of being employed in a STEM field, all non-STEM qualified immigrants are more likely to land a STEM job compared to the native-born. At the same time, having STEM qualifications is associated with the lower chances of STEM employment among male immigrants compared to native-born Germans. Particularly low are returns to STEM qualifications among male immigrants from CEE countries, Turkey, and MENA countries.

Results further indicate that STEM qualifications are associated with somewhat lower occupational status among the native-born German men than non-STEM qualifications. Non-STEM qualified immigrants occupy jobs of lower socio-economic status and lower wages (one exception are immigrants from other European countries) compared to the native-born. STEM qualifications, however, help significantly narrow the gap among all male immigrants to the native-born men. A comparable pattern is observed for wages, although immigrants from Asian countries do not seem to benefit from their STEM qualifications to the same extent as other immigrants.



Among women (see [Table 3](#)), the bulk of immigrants with STEM qualifications have similar employment patterns compared to the native-born. In fact, STEM-qualified native-born women experience more employment entry difficulties than those without STEM qualification – possibly a result of the gate-keeping tendencies against STEM-qualified women. We further observe general difficulties in finding employment among non-STEM qualified immigrant women irrespective of their origin.

Female immigrants without STEM qualification are no different from the native-born women in their patterns of STEM employment. A single exception are CEE women, who are more likely to enter STEM jobs even without STEM qualifications compared to the native-born German women. We also observe that German women with STEM qualifications are significantly more likely to be employed in a STEM field, but the association between having a STEM qualification and STEM job is weaker among women than men. Having STEM qualifications increases the chances of women from Northern, Western, and Southern Europe as well as Turkey and MENA to be employed in STEM jobs compared to German women. In contrast, women from CEE countries underutilize their STEM potential by being diverted from STEM employment.

Female immigrants without STEM qualifications face considerable disadvantages in terms of ISEI and wages compared to the non-STEM qualified native women. Yet immigrant women of non-European origin seem to profit from their STEM qualifications more than native-born women in terms of the occupational status of their jobs. We do not observe any significant benefits of STEM qualifications in terms of wages for either group, including the native-born women.

In the final step, we examine differences in returns to technical and medical STEM fields as well as non-STEM fields between immigrants and the native-born. Results of Model 3 for men ([Table 2](#)) indicate that possessing medical STEM qualifications (compared both to technical and non-STEM fields) is associated with lower levels of unemployment, higher status jobs, and higher earnings among native-born German men. Immigrant men with medical qualifications, on the other hand, face higher unemployment, occupy jobs of lower status and lower wages compared to natives with medical qualifications. At the same time, they experience no particular penalties in entering STEM jobs. Regarding the returns to the technical STEM qualification in terms of employment and wages, immigrant men do not deviate from the patterns observed among the native-born. They, however, face stronger penalties regarding

ISEI of their jobs compared to the native-born men with technical qualifications.

Among women (Table 3), benefits of medical qualifications are strongly pronounced for native-born German women. It is noteworthy that immigrant women with medical diplomas face similar unemployment risks and have similar ISEI of their jobs as the native-born women; they are even more likely to work in STEM jobs than the native-born women with medical qualifications. Yet, their disadvantages in terms of wages are also evident. Immigrant women with technical skills are largely disadvantaged compared to the native-born women with technical STEM qualifications.

## Summary and discussion

In times of growing labour shortages, particularly among the qualified labour force, western countries seek to attract highly-educated immigrants in order to meet the labour demand, stay economically competitive, and ensure countries' high levels of prosperity and political stability amid growing diversity. Yet the question remains whether highly educated immigrants, many of whom possess valuable STEM qualifications, are able to get adequate returns to their skills in the host countries. Contributing to the growing body of international research on the stock and utilization of human capital among immigrant populations (Guetto 2018; Lo Iacono and Demireva 2018; Lancee and Bol 2017), this paper explores the amount of and returns to STEM-related qualifications among skilled immigrants in Germany.

Results of this study demonstrate that since the 1980s, Germany indeed accepted large numbers of skilled and STEM-qualified immigrants. Particularly among the tertiary-educated, many more immigrants possess STEM credentials compared to the German native-born, and the pattern holds for both genders. Despite high levels of STEM-related human capital, an average STEM-qualified immigrant to Germany does not succeed in translating her or his STEM qualifications into STEM employment to the same extent as native-born Germans do. For the rest of labour market outcomes, returns to STEM qualifications among immigrants – particularly men – are higher than or on par with those of the native-born. This study demonstrates that male immigrants manage to narrow the gap to the native-born in terms of occupational status of their jobs, wages, and employment propensities, which largely accords with our first hypothesis. At the same time, STEM-qualified

immigrant women are on average less successful in narrowing the gap to the native-born, suggesting gender-specific variations in returns to STEM qualifications among immigrants and potentially also discrimination tendencies on part of employers (England 1992). These findings lend support to the theoretical arguments emphasizing a more straightforward manner in which STEM skills and credentials (as opposed to non-STEM ones) are transferred to a new setting (Han 2016). Yet, at the same time we find evidence for persisting difficulties encountered by immigrants in realizing their potential both in STEM and non-STEM fields (Friedberg 2000; Kogan *et al.* 2011).

The finding that male immigrants with STEM qualifications in Germany are more successful on a number of labour market indicators in comparison to those without STEM qualifications should not mask two further important pieces of evidence. First, we should be aware that smaller penalties among STEM-educated immigrants in Germany might be a mirror side of stronger disadvantages among immigrants without STEM qualifications. Indeed, male immigrants without STEM qualification face particularly high unemployment risks and work in occupations of significantly lower occupational status. Yet, we also observe that immigrant men are found in STEM occupations more often regardless of whether they possess relevant STEM qualifications or not. Second, it is to be reiterated that our analyses sidestep unqualified immigrants to Germany. The descriptive information points, however, to the fact that over 30% of all immigrants who arrived after the 1980s possess no vocational qualifications, not to mention the unqualified immigrants who dominated the migration inflow to Germany in the 1950–70s (Kalter and Granato 2007). Therefore, our analyses cover just a fraction – yet a growing fraction – of all immigrants to Germany, as the proportion of highly skilled immigrants has been gradually increasing also in this country (Kogan 2011).

In line with the second hypothesis, variation across immigrants' origins in returns to STEM qualifications is also evident. Among men, the most successful group appears to be STEM-qualified Eastern Europeans, who get the highest returns of their STEM human capital in terms of employment, ISEI, and wages. STEM-qualified male immigrants from other European countries, Turkey, and MENA regions are also successful in narrowing the gap to the native-born in occupational status and earnings. Among female immigrants, returns to STEM qualifications are highest for those from Turkey and MENA countries, who manage to narrow the gap to native-born women in terms of access to STEM employment and occupational status of jobs.

A definitive explanation to the origin-specific variation in returns to STEM qualifications cannot be provided with the data at hand. One potential explanation accords with the theoretical ideas regarding the degree of selectivity among STEM-qualified immigrants: STEM-qualified female immigrants from Turkey and MENA countries might be particularly selective in comparison to female immigrants from Eastern Europe, who are known for their higher levels of STEM orientation among the female workforce (Schlenker 2015). At the same time, male immigrants from CEE countries are also not particularly selective with regard to advanced qualifications, yet they enjoy favourable returns to their STEM human capital. It is possible that their skills and credentials, particularly in technical fields, are well transferable into the German setting and German employers perceive them as sufficiently reliable (Brücker *et al.* 2020; Damelang *et al.* 2020). Another explanation is a sharp demand in technical STEM occupations and an apparent readiness of German employers to hire immigrants from CEE countries, with whom they have a lot of experience, particularly since the EU enlargement to the east.

We also find support of the hypothesis addressing the variation in returns to STEM qualifications. Our findings demonstrate that female immigrants with medical qualifications are doing fairly well in the German labour market, having higher rates of STEM employment, similar employment rates, and similar ISEI as the native-born women. Yet, they face significant wage penalties. For female immigrants with technical qualifications, disadvantages are found in practically all outcomes. In contrast, among male immigrants, technical qualifications tend to ensure a parity in outcomes with the native-born, which largely accords with the assumption about easier transferability of technical skills. Yet, we find no equivalence in the transferability of medical qualifications among men. Given that credentials and skills from medical fields are hardly more transferable than those from technical fields, the higher returns to medical STEM qualifications among women are likely attributed to a high demand of medical professions in Germany, particularly – as our results demonstrate – among women. The findings on returns to specific STEM qualifications have to be taken with caution due to small sample sizes in some categories.

Findings of this study provide evidence that Germany might be no worse utilizing the STEM potential of its immigrant population than some North American countries (Boyd and Tian 2017; Picot and Hou 2018; Wright *et al.* 2017). Still, there is space for improvement in employability of STEM-qualified female immigrants as well as better matching of immigrants' STEM skills to the demands of the German labour market

(see also Jinks *et al.* 2000). We conclude that with a policy of attracting STEM-qualified immigrants, facilitating the recognition of their qualifications, and easing German employers' uncertainties, Germany should be well on the way to master current and future challenges in meeting shortages in STEM-qualified labour (Kogan 2012).

This study is a first attempt to describe the patterns of economic returns to STEM qualifications between the native-born and immigrants, whilst differentiating between the immigrant groups in Germany. Future research should concentrate on explaining the differences across origin groups in returns to STEM qualifications. Another possible venue for research would be to explore the differences in returns to STEM qualifications at various levels of education, particularly due to the specifics of vocational education and training in Germany.

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## References

- Aigner, D. J. and Cain, G. G. (1977) 'Statistical theories of discrimination in labor markets', *Industrial and Labor Relations Review* 30(2): 175–87.
- Alba, R., Logan, J., Lutz, A. and Stults, B. (2002) 'Only English by the third generation? Loss and preservation of the mother tongue among the grandchildren of contemporary immigrants', *Demography* 39(3): 467–84.
- Anger, C., Koppel, O., Plünnecke, A., Röben, E. and Schüler, R. M. (2017) MINT-Herbstreport 2018. Institut der deutschen Wirtschaft Köln. Abrufbar unter: <https://www.iwkoeln.de/studien/gutachten/beitrag/christina-anger-sarah-bergero-liver-koppel-axel-pluennecke-mint-herbstreport-2017-368955>. Abruf, 17, 2017.
- Arrow, K. J. (1972) 'Some Mathematical Models of Race Discrimination in the Labor Market'. In A.H. Pascal (ed.), *Racial Discrimination in Economic Life*, Lexington: D. C. Heath, 187–203.
- Baert, S., Cockx, B., Gheyle, N. and Vandamme, C. (2015) 'Is there less discrimination in occupations where recruitment is difficult?', *Industrial & Labor Relations Review* 68: 467–500.
- Becker, G. S. (1964) *Human Capital*, Cambridge: National Bureau of Economic Research.
- Becker, G. S. (1971) *The Economics of Discrimination*, Chicago: University of Chicago Press.
- Blank, R. M., Dabady, M. and Citro, C. F. (2004) *Measuring Racial Discrimination*, Panel on Methods for Assessing Discrimination, National Research Council. Washington, DC: National Academies Press.
- Borjas, G. J. (1987) 'Self-Selection and the Earnings of Immigrants', *The American Economic Review* 77(4): 531–553.
- Borjas, G. J. (1994) 'The economics of immigration', *Journal of Economic Literature*, 32: 1667–1717.
- Boyd, M. and Tian, S. (2017) 'STEM education and STEM work: nativity inequalities in occupations and earnings', *International Migration* 55(1): 75–98.
- Boyd, M. and Tian, S. (2018) 'Is STEM education portable? Country of education and the economic integration of STEM immigrants', *Journal of International Migration and Integration* 19(4): 965–1003.
- BPB (Bundeszentral für politische Bildung) (2005) The German "Green Card". <https://www.bpb.de/themen/migration-integration/kurz dossiers/58174/the-german-green-card/>.
- Bratsberg, B. and Ragan, J. F. (2002) 'The impact of host-country schooling on earnings: a study of male immigrants in the United States', *The Journal of Human Resources* 37: 63–105.
- Brücker, H., Glitz, A., Lerche, A. and Romiti, A. (2020) 'Occupational recognition and immigrant labor market outcomes', *Journal of Labor Economics* 39(2): 497–525.
- Bundesagentur für Arbeit (2017) MINT-Berufe. [https://statistik.arbeitsagentur.de/DE/Statischer-Content/Grundlagen/Klassifikationen/Klassifikation-der-Berufe/KldB2010-Fassung2020/Arbeitsmittel/Generische-Publikationen/Berufsaggregate/MINT-Berufe-Aggregat.pdf?\\_\\_blob=publicationFile&v=8](https://statistik.arbeitsagentur.de/DE/Statischer-Content/Grundlagen/Klassifikationen/Klassifikation-der-Berufe/KldB2010-Fassung2020/Arbeitsmittel/Generische-Publikationen/Berufsaggregate/MINT-Berufe-Aggregat.pdf?__blob=publicationFile&v=8).

- Bundesagentur für Arbeit. Tabellarische Umsteigeschlüssel zur KldB (2010) <https://statistik.arbeitsagentur.de/DE/Statischer-Content/Grundlagen/Klassifikationen/Klassifikation-der-Berufe/KldB2010-Fassung2020/Arbeitsmittel/Umschluesselungstabellen.html>.
- Buzdugan, R. and Halli, S. S. (2009) 'Labor market experiences of Canadian immigrants with focus on foreign education and experience', *International Migration Review* 43: 366–86.
- Caprile, M., Palmén, R., Sanz, P. and Dente, G. (2015) 'Encouraging STEM studies labour market situation and comparison of practices targeted at young people in different member states', *Policy Department A* 12.
- Carliner, G. (2000) 'The language ability of US immigrants: assimilation and cohort effects', *International Migration Review* 34(1): 158–82.
- Chiswick, B. R. (1978) 'The effect of Americanization on the earnings of foreign-born men', *Journal of Political Economy* 86(5): 897–921.
- Chiswick, B. R. (1999) 'Are immigrants favorably self-selected', *American Economic Review* 89(2): 181–185.
- Chiswick, B. R. and Miller, P. W. (2001) 'A model of destination-language acquisition: application to male immigrants in Canada', *Demography* 38(3): 391–409.
- Chiswick, B. R. and Miller, P. W. (2009) 'The international transferability of immigrants' human capital', *Economics of Education Review* 28(2): 162–9.
- Cohen, Y. and Haberfeld, Y. (2007) 'Self-selection and earnings assimilation: immigrants from the former soviet union in Israel and the United States', *Demography* 44(3): 649–68.
- Damelang, A., Abraham, M., Ebensperger, S. and Stumpf, F. (2019) 'The hiring prospects of foreign-educated immigrants: A factorial survey among German employers', *Work, Employment and Society* 33(5): 739–58.
- Damelang, A., Ebensperger, S. and Stumpf, F. (2020) 'Foreign credential recognition and immigrants' chances of being hired for skilled jobs—evidence from a survey experiment among employers', *Social Forces* 99(2): 648–71.
- England, P. (1992) *Comparable Worth. Theories and Evidence*, New York: De Gruyter.
- Engzell, P. and Ichou, M. (2020) 'Status loss: the burden of positively selected immigrants', *International Migration Review* 54(2): 471–95.
- Erdmann, V. and Koppel, O. (2010) 'Demografische herausforderung: MINT-Akademiker', *IW-Trends-Vierteljahresschrift zur Empirischen Wirtschaftsforschung* 37(4): 81–94.
- Esser, H. (2006) *Sprache und Integration: die sozialen Bedingungen und Folgen des Spracherwerbs von Migranten*. Campus.
- Friedberg, R. M. (2000) 'You can't take it with you? Immigrant assimilation and the portability of human capital', *Journal of Labor Economics* 18(2): 221–51.
- Ganzeboom, H. B., De Graaf, P. M. and Treiman, D. J. (1992) 'A standard international socio-economic index of occupational status', *Social Science Research* 21(1): 1–56.
- GESIS Institut. Der Internationale Sozioökonomische Index des beruflichen Status (ISEI). <https://www.gesis.org/missy/materials/MZ/tools/isei>.



- Glass, J. L., Sessler, S., Levitte, Y. and Micheltore, K. M. (2013) 'What's so special about STEM? A comparison of women's retention in STEM and professional occupations', *Social Forces* 92(2): 723–56.
- Gorodzeisky, A. and Semyonov, M. (2017) 'Labor force participation, unemployment and occupational attainment among immigrants in west European countries', *PLoS One* 12(5): e0176856.
- Granato, N. (2000) *Mikrodaten-Tools-CASMIN-Bildungsklassifikation: eine Umsetzung mit dem Mikrozensus 1996*.
- Grigoleit-Richter, G. (2017) 'Highly skilled and highly mobile? Examining gendered and ethnicised labour market conditions for migrant women in STEM-professions in Germany', *Journal of Ethnic and Migration Studies* 43(16): 2738–55.
- Guetto, R. (2018) 'Employment returns to tertiary education for immigrants in Western Europe: cross-country differences before and after the economic crisis', *Social Inclusion* 6(3): 64–77.
- Hahn, E., Richter, D., Schupp, J., Back, M. D., Donnellan, B. and Visser, B. (2019) 'Predictors of refugee adjustment: The importance of cognitive skills and personality', *Collabra: Psychology* 5(1): 23.
- Han, S. (2016) 'Staying in STEM or changing course: do natives and immigrants pursue the path of least resistance?', *Social Science Research* 58: 165–83.
- Heath, A. and Cheung, S. Y. (2007) *The Comparative Study of Ethnic Minority Disadvantage. Proceedings-British Academy, Vol. 137*, Oxford: Oxford University Press for the British Academy.
- Heckman, J. J. (1979) 'Sample selection bias as a specification error', *Econometrica* 47 (1): 153–61.
- Hunkler, C. (2014) *Ethnische Ungleichheit Beim Zugang zu Ausbildungsplätzen im Dualen System*, Wiesbaden: Springer.
- Jinks, C., Ong, B. N. and Paton, C. (2000) 'Mobile medics? The mobility of doctors in the European economic area', *Health Policy* 54(1): 45–64.
- Kalter, F. and Granato, N. (2007) 'Educational hurdles on the way to structural assimilation in Germany. In A. Heath and S. Yi Cheung (eds.), *Unequal chances. Ethnic Minorities in Western Labour Markets*, 271–319. Oxford: Oxford Univ. Press.
- Kalter, F. and Kogan, I. (2014) 'Migrant networks and labor market integration of immigrants from the former soviet union in Germany', *Social Forces* 92(4): 1435–56.
- Kanas, A., Chiswick, B. R., Van Der Lippe, T. and van Tubergen, F. (2012) 'Social contacts and the economic performance of immigrants: A panel study of immigrants in Germany', *International Migration Review* 46(3): 680–709.
- Kanas, A. and van Tubergen, F. (2009) 'The impact of origin and host country schooling on the economic performance of immigrants', *Social Forces* 88(2): 893–915.
- Kogan, I. (2006) 'Labor markets and economic incorporation among recent immigrants in Europe', *Social Forces* 85(2): 697–721.
- Kogan, I. (2011) 'New immigrants – old disadvantage patterns? Labour market integration of recent immigrants into Germany', *International Migration* 49(1): 91–117.
- Kogan, I. (2012) 'Potenziale nutzen! Determinanten und Konsequenzen der Anerkennung von Bildungsabschlüssen bei Zuwanderern aus der ehemaligen

- Sowjetunion in Deutschland', *Kölner Zeitschrift für Soziologie und Sozialpsychologie* 64(1): 67–89.
- Kogan, I. (2016) 'Arbeitsmarktintegration von Zuwanderern'. In H. U. Brinkmann und M. Sauer, *Einwanderungsgesellschaft Deutschland: Entwicklung und Stand der Integration*, 177–200. Wiesbaden: Springer VS.
- Kogan, I., Kalter, F., Liebau, E. and Cohen, Y. (2011) 'Individual resources and structural constraints in immigrants' labour market integration'. In M. Wingers, M. Windzio, H. de Valk, and C. Aybek (eds.), *Labour Market Integration. A Life-Course Perspective on Migration and Integration*, 75–100. London: Springer..
- Kosyakova, Y., Gundacker, L., Salikutluk, Z. and Trübshwetter, P. (2021) Arbeitsmarktintegration in Deutschland: Geflüchtete Frauen müssen viele Hindernisse überwinden, No. 08/2021. IAB-Kurzbericht.
- Laible, M. C. and Brenzel, H. (2021) 'Does personality matter? Noncognitive skills and the male migrant wage gap in Germany', *International Migration Review* 56 (2): 376–409.
- Lancee, B. (2012) 'The economic returns of bonding and bridging social capital for immigrant men in Germany', *Ethnic and Racial Studies* 35(4): 664–683.
- Lancee, B. (2016) 'Job search methods and immigrant earnings: a longitudinal analysis of the role of bridging social capital', *Ethnicities* 16(3): 349–67.
- Lancee, B. and Bol, T. (2017) 'The transferability of skills and degrees: why the place of education affects immigrant earnings', *Social Forces* 96(2): 691–716.
- Lissitsa, S. and Chachashvili-Bolotin, S. (2019) 'Enrolment in mathematics and physics at the advanced level in secondary school among two generations of highly skilled immigrants', *International Migration* 57(5): 216–34.
- Lo Iacono, S. and Demireva, N. (2018) 'Returns to foreign and host country qualifications: evidence from the US on the labour market placement of migrants and the second generation', *Social Inclusion* 6(3): 142–52.
- Oesingmann, K. (2016) 'Ifo migrationsmonitor: Die zuwanderung von ausländischen studierenden nach deutschland—ein wichtiger faktor für die gewinnung von Fachkräften', *Ifo Schnelldienst* 69(20): 51–55.
- Organisation for Economic Co-operation and Development (OECD) Staff (2017) *OECD Skills Outlook 2017: Skills and Global Value Chains*, Paris: OECD.
- Phelps, E. S. (1972) 'The statistical theory of racism and sexism', *American Economic Review* 62(4): 659–61.
- Picot, G. and Hou, F. (2018) 'Immigrant STEM workers in the Canadian economy: skill utilization and earnings', *Canadian Public Policy* 44(S1): S113–S124.
- Portes, A. (1998) 'Social capital: its origins and applications in modern sociology', *Annual Review of Sociology* 24(1): 1–24.
- Portes, A. and Rumbaut, R. G. (2001) *Legacies: The story of the immigrant second generation*. London: University of California Press.
- Quadlin, N., Cohen, E. D. and VanHeuvelen, T. (2021) 'Same major, same economic returns? College selectivity and earnings inequality in young adulthood', *Research in Social Stratification and Mobility* 75: 100647.
- Quadlin, N. and Conwell, J. A. (2021) 'Race, gender, and parental college savings: assessing economic and academic factors', *Sociology of Education* 94(1): 20–42.

- RDC of the Federal Statistical Office and Statistical Offices of the Federal States. [Microcensus], survey years 2015, 2016, own calculations.
- Ricci, A., Crivellaro, F. and Bolzani, D. (2021) 'Perceived employability of highly skilled migrant women in STEM: insights from labor market intermediaries' professionals', *Administrative Sciences* 11(1): 7.
- Ryan, D., Dooley, B. and Benson, C. (2008) 'Theoretical perspectives on post-migration adaptation and psychological well-being among refugees: towards a resource-based model', *Journal of Refugee Studies* 21(1): 1–18.
- Schimpl-Neimanns, B. (2004) 'Zur umsetzung des internationalen sozioökonomischen index des beruflichen status (ISEI)', *ZUMA-Nachrichten* 54: 154–70.
- Schlenker, E. (2015) 'The labour supply of women in STEM', *IZA Journal of European Labor Studies* 4(1): 1–17.
- Schmidt, R., Kristen, C. and Mühlau, P. (2021) 'Educational selectivity and immigrants' labour market performance in Europe', *European Sociological Review* 38 (2): 252–68.
- Spörlein, C. and Kristen, C. (2019) 'Educational selectivity and language acquisition among recently arrived immigrants', *International Migration Review* 53(4): 1148–70.
- Stumpf, F., Damelang, A., Abraham, M. and Ebensperger, S. (2020) 'How national institutions shape skilled immigrants' chances of getting hired: evidence from harmonised factorial surveys with employers in Germany and England', *KZfJSS Kölner Zeitschrift für Soziologie und Sozialpsychologie* 72(1): 351–73.
- Tibajev, A. and Hellgren, C. (2019) 'The effects of recognition of foreign education for newly arrived immigrants', *European Sociological Review* 35(4): 506–21.
- VanHeuvelen, T. and Quadlin, N. (2021) 'Gender inequality in STEM employment and earnings at career entry: evidence from millennial birth cohorts', *Socius* 7: 23780231211064392.
- Van Tubergen, F. and Kalmijn, M. (2009) 'Language proficiency and usage among immigrants in The Netherlands: incentives or opportunities?', *European Sociological Review* 25(2): 169–82.
- Wright, R., Ellis, M. and Townley, M. (2017) 'The matching of STEM degree holders with STEM occupations in large metropolitan labor markets in the United States', *Economic Geography* 93(2): 185–201.
- Wrobel, M. (2021) 'Determinants of successful labour market integration as exemplified by the German green card programme', *Journal of Ethnic and Migration Studies* 47(17): 4135–54.
- Zeng, Z. and Xie, Y. (2004) 'Asian-Americans' earnings disadvantage reexamined: the role of place of education', *American Journal of Sociology* 109: 1075–108.