

Article

German Labor Emigration in Times of Technological Change: Occupational Characteristics and Geographical Patterns

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Abstract: Technological change has altered labor market demands within well-developed societies implying global competition for skilled labor and, as a consequence, new forms of labor migration. So far, patterns of this labor migration have been underexplored. Thus, the article analyzes characteristics, geographies and possible underlying drivers of workers migrating from Germany as an exemplary case for a well-developed country. Relying on probability-based and unique data, our findings reveal that, besides demand for people with higher levels of education, performing specific occupational tasks is also in demand in the global competition for talent. Hence, Germans in jobs with a high proportion of analytical non-routine tasks are more likely to emigrate than those with predominantly manual routine tasks. Moreover, the results show that global discrepancies concerning the technological development between the country of origin and the country to which they emigrate are a crucial contextual driver attracting this specifically demanded work force. Workers mainly performing analytical non-routine tasks within their job tend to move to countries which are technologically more developed than Germany while individuals performing jobs with a high share of non-routine manual or interactive tasks tend to emigrate to countries that are less technologically developed than Germany.



Citation: Décieux, J.P.; Mergener, A. German Labor Emigration in Times of Technological Change: Occupational Characteristics and Geographical Patterns. *Sustainability* **2021**, *13*, 1219. <https://doi.org/10.3390/su13031219>

Received: 30 December 2020

Accepted: 20 January 2021

Published: 25 January 2021

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Keywords: global competition; skilled labor; technology; migration; highly developed countries; task approach; Germany

1. Introduction

Technological change has a tremendous impact on employment structures and is a driver of international migration [1] as the demand for skills and knowledge has undergone substantial changes in many Western labor markets. Through the automation of work tasks using computer technology, low-skilled human tasks that involve a high degree of routine work in particular can be substituted. In contrast, the transition to postindustrial economies with the expansion of knowledge-based tasks increase the demand of well-educated persons performing tasks that require a high level of non-routine analytical and creative work. In those cases, computerization usually leads to a complementation of the workforce and productivity. Moreover, jobs with a high share of non-routine manual tasks remain largely unaffected by technological change. Using the *task approach*, Autor, Levy and Murnane [2] describe this phenomenon of job polarization and recent studies empirically reflected this approach within a large number of technologically developed countries, including Germany (see e.g., Antonczyk, DeLeire, and Fitzenberger [3], Spitz-Oener, [4] for Germany; Autor and Dorn [5] for the U.S., or Goos, Manning, and Salomons [6] for 16 Western European countries). At the same time, it has been observed that both a large number of well-trained and a non-neglected number of lower educated employees have left Germany for occupational reasons [7].

There seems to be international competition for labor, but we know very little about the characteristics and the geographies of German emigrants (in particular with regard to destination countries) and possible underlying drivers behind their migration patterns. Assuming that emigrants' decision-making processes are rational and migration is an investment in human capital [8], migrants' labor situation should benefit from migration. Following the approaches of recent studies on migration decisions, such perceived benefits may be found not only at the individual but also at the contextual level, considering, for example, the technological development status in a country that can be favorable for migrants, e.g., in terms of agglomeration effects [9]. This implies, on the one hand, that countries that are more advanced in terms of technology than Germany should be more attractive for workers performing analytical non-routine tasks. On the other hand, it can be assumed that workers who carry out jobs with predominantly routine tasks face a lower demand from the technological change perspective. Consequently, the latter group of workers may be more likely to move to countries where the technological development of the labor market is less advanced compared to Germany and thus the risk of being substituted by automation processes is lower.

So far, such patterns of labor migration in times of technological change are under-researched. Existing studies focus mostly on labor migrants' individual benefits and their socioeconomic situation, such as the positive selection of younger and better educated individuals [10]. In order to gain deeper insights into this highly relevant and current topic, we examine in this paper both characteristics of German labor emigrants, focusing on education and occupational tasks, and characteristics of geographies of labor migration, concentrating on the status of technological development of the emigration countries. In particular, we ask the following research questions: *What are the educational and occupational profiles of German labor emigrants? What do we know about emigration countries and their technological levels? Are there differences in the level of technological development of the emigration country between people in jobs with mainly non-routine analytical, interactive or manual tasks and people with routine tasks?*

To answer these questions empirically, we rely on a matched data set combining probability-based data of the German Emigration and Remigration Panel Studies (GERPS) [11], the German Socioeconomic Panel (GSOEP) [12] and the German Federal Institute for Vocational Education and Training (BIBB)/Federal Institute for Occupational Safety and Health (BAuA) Employment Survey [13]. GERPS provides us with unique data on German emigrants from the year 2019. GSOEP covers information of their non-mobile German counterparts (stayers). The BIBB/BAuA Employment Survey 2018 enables us to obtain detailed information about the occupational tasks of German employees. By matching this task information to the occupation of both emigrants and stayers, we obtain a unique database for processing our research questions.

In this way our article contributes to the existing research concerning the following aspects. First, based on highly current data, we present both educational profiles of German emigrants and their occupational task structures. Second, the article reflects differences concerning the technological status between emigration country and country of origin as a central contextual driver of international migration between highly developed countries. Third, it contributes to the ongoing debate on geographies of migration flows with respect to skill levels by complementing the discussion on the positive selection of emigrants with a more fine-grained task-specific perspective.

2. Conceptual Framework and Hypotheses

2.1. International Labor Migration

Within the last few decades, the structure of labor markets has changed—particularly in highly developed countries [1,14,15]. International labor markets no longer demand immigrant workers only in the secondary, low-paid sector coming from less-developed countries, which was the classic form of labor migration after the Second World War [16]. Moreover, for many jobs, the nation state is no longer the essential context for professional

activity [17,18]. Nowadays, we increasingly observe a global “race for talent” [15], which refers to the worldwide competition for elite subgroups, well-educated and skilled specialists [19]. This global competition for talent leads, on the one hand, to an increased demand for mobile workers with competencies that are transferable between companies. On the other hand, professionals possessing the requested skills are usually free to choose where they want to work [20,21].

Concerning this free choice of working environment, international migration research focusing on voluntary migration suggests that voluntary migration decisions are usually based on certain aspirations and motivation bundles that can be reflected by different theoretical perspectives [22]. Basic neoclassical economic models assume that migration decisions of workers are usually rational cost-benefit decisions that aim at achieving economic success or other rewards [23]. Accordingly, the individual’s decision to emigrate is based on a calculation of the expected material and immaterial costs and benefits of migration, weighed against the returns of remaining in the country of origin. If the calculated returns of migration are greater than staying in the country of origin, the individual decides to migrate [8,24]. These processes usually result in a positive self-selection of labor migrants, which are typically younger and better educated than the average population of a country. Reasons for this self-section are twofold; the mostly better international transferability of academic degrees compared to non-academic degrees, e.g., [25,26], and by this the higher expected financial returns from spatial mobility, e.g., [10,27]. Moreover, individuals with higher levels of education are expected to have lower non-economic migration costs, due to, e.g., broader friendship networks and a smoother adaptation process in the country to which they emigrate, e.g., [28,29].

Besides characteristics of the individual level, transnational migration theories [30,31] call for the consideration of the socioeconomic environments at both ends of the migration process, the situation in the country of origin and in the emigration country. Here, research assumes that disparities between world regions can work as a major driver of international migration (e.g., [10]). In those cases, migrants again weigh costs and benefits, but they do so in terms of country-level characteristics. Since we focus on Germany, a highly developed and typical immigration country [32], it can be assumed that for Germans there are no strong negative disparities between their country of origin and their emigration country in terms of general characteristics, such as political structure, health system or living and security standards. Thus, on the one hand, it is to be expected that competition exists primarily with other highly developed countries and, on the other hand, that this competition is mainly evident in terms of structural characteristics in which Germany is not a forerunner. Therefore, we focus on country differences concerning their technological development status as a contextual factor that affects workers’ labor market opportunities through occupational changes and is moreover considered to be a crucial driver of international labor migration [1,32].

2.2. Technological Development and Occupational Change in Highly Developed Countries

Technological transformations, e.g., automation processes, digital networking, and the increasing use of mobile and digital information and communication technology are changing the world of work. In many Western labor markets, which are experiencing strong technological changes, the demand for knowledge and skills has changed significantly [33]. With reference to the hypotheses of a skill-biased technical change (SBTC), especially highly qualified workers can benefit from these technological developments, e.g., [34,35]. The idea behind SBTC is that, on the one hand, highly skilled workers mainly perform non-routine analytical and cognitive tasks, e.g., managing or creative thinking. On the other hand, performing routine and programmable tasks requires fewer years of education for workers. As machines can more often replace routine and programmable tasks rather than analytical and creative tasks, the demand for jobs with a high proportion of analytical tasks is increasing. Hence, technological change usually leads to an upward shift in the employment structure promoting mainly high-skilled occupations [36].

With the critical view that the SBTC is not sufficient to understand the impact of technology on the occupational structure, Autor, Levy and Murnane [2] have put forward a more refined theory with the task approach. The arguments of the task approach are that neither tasks that are easily routinized by technology are necessarily among the lowest-skill jobs, nor tasks where technology has little impact are necessarily the highest-skilled jobs. Thus, the authors claim to distinguish between skills, as workers' characteristics, on the one hand, and tasks, as job characteristics, on the other hand. Manual routine tasks, for example, cannot only be found within production or craft occupations but also in computing or information-processing jobs that are also performed by highly skilled workers. In contrast, interactive, communication or service tasks that are (still) little affected by technological change occur in many low-skilled occupations, such as shop assistants or waiters, e.g., [36]. Simply focusing on workers' educational level to assess labor demand and returns, i.e., applying the standard human capital approach, is often insufficient to reflect the influence of technological change on the labor market [35].

Thus, the consideration of tasks as job characteristics is crucial for assessing labor demand in times of technological change and, therefore, even decisive when studying international labor migration. However, this perspective is underexplored so far. Instead, the focus of labor migration research was primarily on the educational level of workers or specific occupational case studies [35], revealing associations with country-specific characteristics—including countries' technological development status.

2.3. Spatial Patterns of International Labor Migration in the Context of Technological Change

An examination of migration flows shows that particularly high-skilled migration within Organization for Economic Cooperation and Development (OECD) countries is on the rise, as it increased by 68% between 1990 and 2010 to 10.2 million [16]. Moreover, it is well known that there are differences between the countries with regard to their attractiveness to (especially high-skilled) workers. While countries with a low-skills environment are less attractive, e.g., Italy, Greece, Mexico or Turkey, countries with an excellent skills environment, e.g., Canada, Sweden, Ireland, Switzerland or Norway are particularly interesting for highly qualified potential migrants [37]. Regarding the latter group of countries, this leads to an agglomeration of highly skilled workers, which results in a multiplier effect that usually supports technological development and boosts innovation and productivity outcomes [9]. Positive effects of highly skilled migration flows and national diversity on a country's technological development have been widely observed for the U.S. e.g., [38–41] and several European countries, e.g., [42–44]. However, the following research gaps become apparent in this context.

First, the positive correlation between a countries' level of technological development and the migrants' skill structure should not be attributed solely to individuals' education. As mentioned above, labor demand due to technological change mainly concerns the demand for specific tasks of workers that are related to education but do not completely overlap. Thus, when considering the attractiveness of emigration countries with a high level of technological development, particularly non-routine analytical tasks should be in demand. This needs to be empirically examined. Second, even if we know that technologically advanced countries are more attractive to highly skilled emigrants, there is little evidence that less technologically developed countries are of interest. It could be assumed that, on the one hand, the automation risk of human tasks that involve a high degree of routine work is lower in less technologically developed countries, leading to higher attractiveness for routine workers. On the other hand, these countries could as well be interesting for emigrants performing jobs with a high share of non-routine manual or interactive tasks as they remain largely unaffected by technological change. To fill these research gaps, we empirically address these aspects in this article.

2.4. Hypotheses

Based on the assumptions described in the theoretical framework and focusing on the case of Germany, we derive the following hypotheses. In order to prove both the status quo regarding the educational structure of international mobiles also for German emigrants and additionally the association between specific occupational tasks and emigration behavior, we assume that:

Hypothesis 1a (H1a). *German labor emigrants are more highly educated than non-mobile Germans.*

Hypothesis 1b (H1b). *Germans performing jobs with a high proportion of analytical non-routine tasks are more likely to emigrate than Germans in jobs with predominantly manual routine tasks.*

The second hypothesis considers the attractiveness of emigration countries, assuming that countries that are technologically more developed than Germany are generally more interesting for emigrants.

Hypothesis 2 (H2). *Germans are more likely to emigrate to countries that are more advanced than Germany in terms of technological developments.*

Considering differences in the attractiveness of countries in times of technological change by taking into account occupational task structures, our third hypothesis is:

Hypothesis 3 (H3). *Germans performing jobs with a high proportion of analytical non-routine tasks are more likely to emigrate to countries that are more technologically advanced than Germany, while German emigrants in jobs with predominantly manual routine tasks or manual or interactive non-routine tasks tend to move to countries that are less advanced.*

3. Data and Methods

Our analyses rely on a pooled data set of probability-based surveys. First, the German Emigration and Remigration Panel Study (GERPS) provides representative data on internationally mobile Germans, i.e., Germans who moved abroad between 2017 and 2018 [11]. Second, the German Socio-Economic Panel Study (GSOEP) offers information on the German resident population and thus allows us to deduce Germany's non-mobile population [12]. Third, the BIBB/BAuA Employment Survey enables us to obtain detailed information about the occupational tasks of Germans [13]. By matching this task information to the occupations of German emigrants and stayers, we obtain a unique database for processing our research questions.

Following Ette and Witte [10], matching GERPS and GSOEP is an almost ideal basis for an empirical modelling of emigration decisions. GERPS is based on a probability-based sample drawn from local population registers. It covers German citizens who have either emigrated from Germany or re-emigrated to Germany during the period between June 2017 and May 2018 (Ette et al., 2020). GERPS participants received a letter with an invitation to answer an online questionnaire mainly including questions about employment, family life, health, and social cohesion ("push-to-web approach" [45]). The study was conducted between November 2018 and February 2019. About 12,000 interviews with internationally mobile individuals were conducted. The analysis of this paper relies only on the 'emigrant sample' of GERPS, which consist of about 5000 surveys with recent emigrants in 130 countries all around the globe (response rate of about 31%). Most of the German emigrants covered by GERPS moved to Switzerland (21.9%), Austria (10.7%), the United States (8.6%), the United Kingdom (7.8%), and France (6.1%). With regard to the overall distribution of emigration countries, these results are largely in line with official migration statistics provided by the German Federal Statistical Office [46]. As our research questions focuses on labor migration, our analysis sample was restricted to individuals in

employment. Furthermore, respondents with missing information in the relevant variables were excluded. This resulted in a total number of 2423 emigrants for analysis.

The GSOEP is a wide-ranging probability based multi-cohort study of the population living in Germany. Every year, around 30,000 persons in about 15,000 households are surveyed [12]. As part of the analytical approach of this paper, GSOEP provides a control sample of internationally non-mobile Germans, allowing us to assess differences between stayers and internationally mobile movers. We used data from 2017, limiting the dataset to German citizens. Furthermore, we excluded respondents without a job or with missing data in the dependent variables and individuals who had moved—internally within Germany or internationally—between 2015 and 2017. This resulted in 9818 non-mobile individuals in our ‘German stayer sample’.

The BIBB/BAuA Employment Survey is a representative study containing information of more than 20,000 persons in active employment on the German labor market (doi:10.7803/501.18.1.1.10). The great advantage of this dataset is that it provides rich information on job tasks relating to workers’ current main job. Hence, the data has been widely used to apply the task approach to Germany, e.g., [3,4,47]. In this paper, we rely on 16 detailed tasks information, bundled in three categories (non-routine analytic, non-routine manual/interactive and routine manual) and averaged over workers’ main job (for details see Section 3.2). Main job information is available as occupational codes at the 5-digit level of the German classification of occupations, 2010 edition (KldB 2010). Using these codes, we link the tasks to the occupations of the individuals from GERPS and GSOEP, obtaining a unique database to address our research questions.

3.1. Dependent Variables

For the analysis of hypothesis 1a and 1b, focusing on *emigration probabilities* of German citizens, the dependent variable is defined as “1” if the person lived abroad at the time of the GERPS survey (‘Emigrant’) and as “0” if the respondents lived in Germany and has not moved within the last three years (‘Stayer’).

For answering Hypothesis 2 and 3, reflecting the technological standard in the emigration country as a driver for international migration, the dependent variables are based on the IMD World Digital Competitiveness Ranking [48]. This ranking is an internationally renowned measurement approach providing country level data on how 63 countries stand in the process of digitization. The ranking is based on one composite score that reflects the general capacity to adapt new technologies as well as on three sub scores that measure digital competitiveness in specific areas: first, knowledge, to assess the existence of know-how necessary to discover, understand and create new technologies (e.g., talent, education and training); second, technology referring to information about the technical infrastructure, capital and a regulatory framework enabling the development of digital technologies; third, future readiness emphasizing the degree of flexibility to creativity and innovation such as adaptive attitudes, agility and IT integration, e.g., within the business sector of the country. By subtracting the German scores (overall: 86.22; knowledge: 83.1; technology: 71.1 and future readiness: 83.4) from the respective domain score of the emigration country that the respondent moved to, we developed four indicators reflecting the technological distance between the emigration countries and Germany as dependent variables: $\Delta(\text{Overall Technological Development})$, $\Delta(\text{Knowledge})$, $\Delta(\text{Technology})$, and $\Delta(\text{Future readiness})$. In all four distance measures, positive (greater 0) values indicate a move to a technologically better developed country compared to Germany and negative values direct to a move to a technologically less developed country.

3.2. Explanatory Variables

For H1a, our predictor variable is the *educational level*, differentiating between German emigrants and stayers with vocational education, higher (academic) education or no vocational degree.

The main explanatory variables for H1b and H3 are job tasks relating to workers' current occupations. These are self-reported tasks selected from a list of tasks in the BIBB/BAuA Employment survey. Referring to Rohrbach-Schmidt and Tiemann [47], we bundle single tasks into categories as follows:

Non-routine analytic tasks include in detail "organizing, making plans and decisions, working out operations", "researching, evaluating, developing, constructing", "gathering information, investigating, documenting", "teaching, training, education" and "consulting, advising".

Non-routine manual/interactive tasks comprise "accommodating, preparing food, and serving", "taking care, and healing", "cleaning, recycling, waste disposal", "purchasing, procuring, selling", "promoting, marketing, public relations". We combine non-routine manual and interactive tasks into one category as the specific distinction is not decisive for our research question and thus we have roughly the same number of single items in the three categories.

Routine manual tasks contain "manufacturing of goods, planting", "measuring, testing", "operating, controlling machines", "repairing, renovating, restoring", storing, transporting, shipping, stocking, posting", "protecting, guarding, observing, controlling traffic".

In order to bundle the single tasks, we calculate a sum index for each of the three task categories following the approach of Alda [49]. This approach reflects the average intensity of the respective tasks (measured in three intensities: frequently (2), sometimes (1), and never (0)) on a scale from 0 to 100%. We then aggregate the tasks bundles across occupations at the 5-digit level of the German classification of occupations and add them to the occupations of emigrants and stayers.

3.3. Analytical Strategy and Control Variables

To reflect the relation between occupational tasks and the different dependent variables covering individuals' migration decisions, we estimated logit regression models [50] to test H1a and H1b and ordinary least squares (OLS) regressions [51] for those reflecting the technological level of the emigration country (measured as continuous variables) to proof H3.

Our analyses include several controls. Since research points out that migration decisions depend not only on economic considerations but are also significantly influenced by the specific social situation of the individual, all models control for different characteristics of the respondents. Ette, Sauer and Fauser [52], for instance, argue that migrations are interdependently related to other domains of the individual life course and to the life course of potential partners or family members. In line with that, the new economics as well reflect non-economic drivers of emigration [53,54]. Empirically, this means for example that the sociodemographic and respondent's family situation may influence the decision whether and where to move. Therefore, we control for respondents' *age*, and *gender* to account for gender- or age-related differences in the propensity to migrate [10]. Moreover, we consider the existence of a spouse or children in the country of origin before the (possible) migration which may reduce the propensity for emigration [55,56]. Additionally, we control for respondents' educational degree [10] and assume that the sector or industry the respondents were active before migration as well as changes in the respondents' occupation in the course of migration [57] may influence the migration decision. Finally, we account for respondent's risk attitude [58,59], health status [60,61] and migration background [62] as research suggests that these may influence the individual migration decision. Table 1 provides the descriptive statistics for all variables included in our analyses.

Table 1. Descriptive statistics ($N = 12,240$).

	Stayer (GSOEP)		Emigrants (GERPS)		Whole Sample	
	Mean/Prop.	SD	Mean/Prop.	SD	Mean/Prop.	SD
Main task: Intensity of ...						
... non-routine analytic tasks	53.23	17.16	63.79	12.22	55.38	16.83
... non-routine manual/interactive tasks	27.25	15.65	23.22	13.35	26.43	15.30
... routine tasks	33.04	16.46	26.02	12.82	31.61	16.04
Vocational Degree						
No Degree	0.14		0.05		0.12	
Vocational Education	0.58		0.18		0.50	
Higher Education	0.28		0.77		0.38	
Age	46.05	12.36	37.93	9.89	44.40	12.34
Gender (Male)	0.53		0.47		0.52	
Partnership Status	0.72		0.78		0.73	
Children in the household	0.44		0.17		0.39	
Migration Background	0.16		0.24		0.18	
Health status						
(Very) good	0.55		0.85		0.61	
Medium	0.33		0.13		0.29	
(Very) bad	0.12		0.03		0.10	
Risk attitude	4.86	2.27	6.06	2.07	5.11	2.28
Sector						
Construction	0.05		0.02		0.04	
Mining, quarrying	0.00		0.00		0.00	
Energy and water supply, waste management	0.01		0.02		0.02	
Financial and insurance services	0.04		0.05		0.04	
Professional, scientific, and technical services	0.05		0.05		0.05	
Provision of other services	0.06		0.03		0.05	
Provision of other economic services			0.04		0.01	
Education	0.09		0.05		0.08	
Accommodation and food service activities	0.03		0.03		0.03	
Human health and social work activities	0.15		0.09		0.14	
Real estate activities	0.01		0.01		0.01	
Wholesale and retail trade; repair of motor vehicles	0.11		0.02		0.09	
Information and communication	0.03		0.08		0.04	
Arts, entertainment, and recreation	0.01		0.03		0.02	
Agriculture, forestry, and fishing	0.01		0.01		0.01	
Public administration, defense, compulsory social security	0.08		0.03		0.07	
Manufacturing	0.19		0.08		0.16	
Transportation and storage	0.04		0.02		0.04	
Other	0.03		0.34		0.09	

Data: German Emigration and Remigration Panel Study (GERPS)-German Socio-Economic Panel Study (GSOEP)-Federal Institute for Vocational Education and Training (BIBB)/Federal Institute for Occupational Safety and Health (BAuA) Employment Survey, authors' own calculations.

4. Results

4.1. Skills and Occupational Tasks of German Labor Emigrants

Table 2 shows three models reflecting the relationship between the individual level of education and the individual probability of emigration, as well as between the task profile of the occupation the individuals work in and the individual probability of emigration. All three models control for the aforementioned individual characteristics and contextual factors.

Table 2. Average marginal effects (AME) of logistic regressions on emigration probability.

	Model 1a Education	Model 1a Tasks	Model 1a Education and Tasks
Education: (Ref.: Vocational Education)			
No Degree	−0.034 *** (0.007)		−0.035 *** (0.008)
Higher Education	0.192 *** (0.007)		0.139 *** (0.008)
Task profiles: Intensity of . . .			
. . . non-routine analytic tasks		0.004 *** (0.000)	0.002 *** (0.000)
. . . non-routine manual/ interactive tasks		−0.001 *** (0.000)	−0.000 (0.000)
. . . routine tasks		−0.002 *** (0.000)	−0.001 *** (0.000)
Observations	12,241	12,241	12,241
Pseudo R ²	0.517	0.488	0.530

Data: GERPS-GSOEP-BIBB/BAuA-Employment Survey, authors' own calculations. Note: Coefficients = AME; Standard errors in parentheses; * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$, Controls for respondents Age, Age2, Gender, Partnership status, Children in the Household, Migration Background, Health status, Risk attitude, and Sector are included but not displayed.

Model 1a reflects the relationship between the educational level of a worker and his or her probability to become internationally mobile and emigrate. Here it becomes apparent, that the educational degree correlates significantly with the possibility of a migration. People with lower levels of education are significantly less likely to be internationally mobile compared to those with a vocational degree. In contrast, individuals with a higher education degree are significantly more likely to emigrate than those with a vocational education. Thus, we can support H1a that German labor emigrants are higher educated than non-mobile German workers.

Model 1b reflects the relation between workers' task profiles and their probability of becoming internationally mobile. It shows a statistically significant relation between the individual task profiles and individual mobility behavior. While jobs with a high share of non-routine analytical tasks correlate positively with the individual probability of emigration, non-routine manual or interactive tasks or routine tasks show a negative correlation to the probability of becoming a work migrant. Model 1c shows the full model reflecting both relations in one model. Here it becomes apparent that both the relationship between education and the probability of emigration and the relationship between the task profile and the probability of emigration remain largely the same. Merely the negative correlation between the intensity of non-routine manual or interactive tasks and emigration ceases to be statistically significant in the full model. Referring to H1b, we can corroborate that Germans performing jobs with a high proportion of analytical non-routine tasks are more likely to emigrate than Germans in jobs with predominantly manual routine tasks. Moreover, we found that these relationships hold even when considering individuals' level of education.

4.2. Technological Development Status of Emigration Countries

As previous research has already shown [7], the central emigration countries of German workers are on the one hand direct neighbor countries (see Table A1 in the Appendix A) such as Switzerland, Austria, France, or Netherlands. For those countries the low spatial distance to Germany as country of origin is certainly a central reason for the selection of the emigration country. However, on the other hand, Table A1 shows that a large number of emigrations covered a much greater spatial distance, given that more than 10% of all emigrants moved to the US or Canada, more than 3% moved to China or Japan, and even about 1% to smaller countries such as Singapore.

In order to assess H2 stating that German workers are more likely to emigrate to countries that are technologically more advanced than Germany, Table 3 reflects the differences between the technological status in Germany and in the emigration countries across an overall score and three different sub areas of technological development.

Table 3. Differences between technological status of Germany and the emigration countries, overall and in different sub areas.

Variable	N	Mean	SD	Min	Max
Δ (Overall Technological Development)	2640	2.590	9.100	−30.090	13.780
Δ (Knowledge)	2640	−0.530	9.870	−37.580	7.930
Δ (Technology)	2640	8.660	8.950	−23.490	28.990
Δ (Future readiness)	2640	−0.360	10.330	−35.190	15.070

Data: GERPS, authors' own calculations.

German emigrants tend to emigrate to countries that are technologically more developed than Germany. Concerning the composite score of overall technological development, we found an average distance of 2.6 between Germany and the emigration country. When taking a closer look on the sub-indices it becomes apparent that the technological infrastructure seems to be the major driver of this distance: the sub domain technology showed an average distance of 8.5 referring to a strongly better technologically developed infrastructure in the emigration country compared to Germany. In both other subdimensions knowledge, focusing on the know-how and skills needed to create innovation in a country, and future readiness, reflecting creativity and agility within a country, slightly negative distances close to zero can be detected, which refer to competitive and marginally better developments concerning skills, agility and creativity in Germany. Thus, H2 stating that German workers are more likely to emigrate to countries that are technologically more advanced than Germany can be supported. More precisely, this seems to be a matter of technological infrastructure and not necessarily a matter of know how or agility in Germany. In order to gain deeper insights regarding these emigration countries, Figure 1 illustrates the technological status of the different emigration countries with respect to the two relevant dimensions Δ (Overall Technological Development) and Δ (Technology). The point of intersection of X- and Y-Axis represents the development status of Germany.

It becomes obvious that nearly all popular emigration countries are above the X-axis, pointing to a better technological standard in the sub area technology, explicitly referring to a better infrastructure to produce technological innovation. Moreover, most of those popular emigration countries and at least those with larger spatial distances to Germany can be found at the right side of the Y-axis, referring to a better overall standard of technology in the emigration country. These are, for instance, Singapore, United Arab Emirates, U.S., and Scandinavian countries.

Moreover, we find many emigration countries under the X-axis and the left side of the Y-Axis, indicating less technologically developed countries compared to Germany. These are, for example, Columbia, Brazilian, Indonesia, Turkey, Greece, or South Africa to which German workers have emigrated.

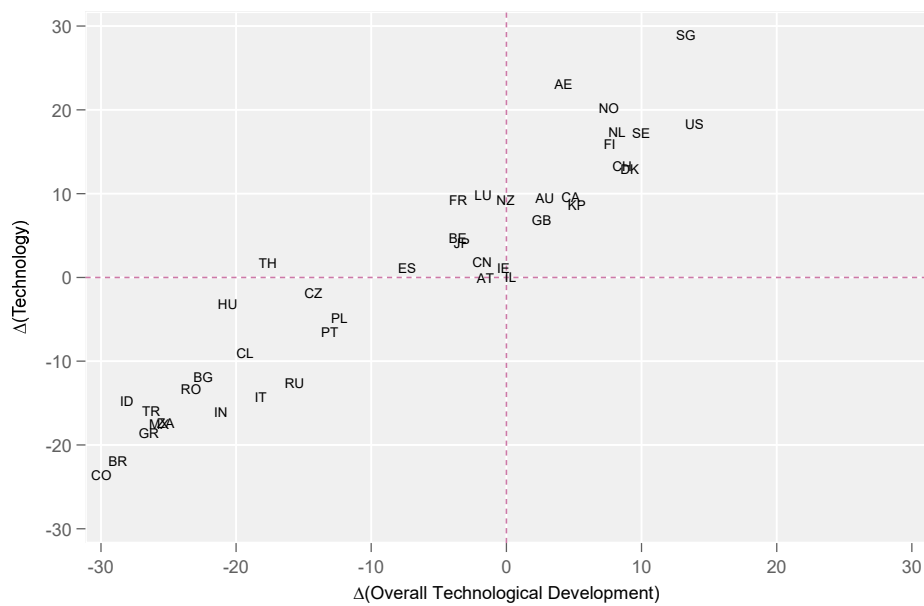


Figure 1. Distances between Germany and different emigration countries concerning the overall technological development and the sub area technology. Data: GERPS, authors’ own calculations.

4.3. Emigrants’ Occupational Tasks and the Technological Development Status of the Emigration Country

H 3 refers to task-specific preference patterns regarding a country of emigration. We suppose that Germans performing jobs with a high proportion of analytical non-routine tasks are more likely to emigrate to countries that are more technologically advanced than Germany while German emigrants in jobs with predominantly manual routine tasks or manual or interactive non-routine tasks tend to move to countries that are less advanced. Linear regression models, shown in Figure 2, reflect these patterns controlling for individual education status and other socioeconomic variables.

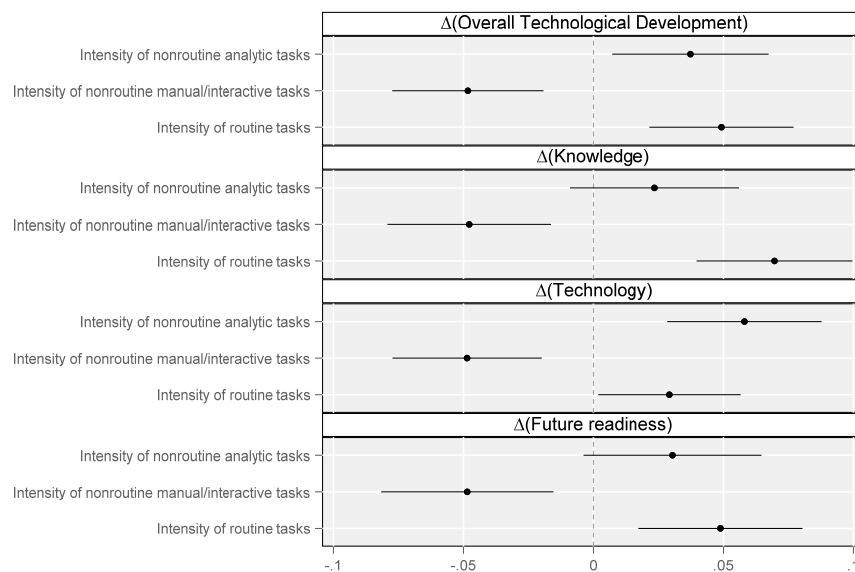


Figure 2. Linear regressions on overall technological development and the sub areas knowledge, technology and future readiness using emigrants’ job tasks (controls included but not displayed). Data: GERPS-BIBB/BAuA-Employment Survey, authors’ own calculations. Note: Coefficients = AME; Controls for respondents’ Educational level, Age, Age², Gender, Partnership status, Children in the Household, Migration Background, Health status, Risk attitude, and Sector are included but not displayed.

Emigrants performing jobs with a high intensity of non-routine analytical tasks are more likely to emigrate to more technologically developed countries than Germany ($\Delta(\text{Overall Technological Development})$). This statistically significant finding is again mainly driven by distances of the technological infrastructure between Germany and the emigration country ($\Delta(\text{Technology})$), while discrepancies concerning know-how ($\Delta(\text{Knowledge})$) and or agility ($\Delta(\text{Future readiness})$) seem to play no significant role. Focusing on non-routine manual or interactive tasks it becomes obvious that larger intensities of non-routine manual or interactive tasks within a job seem to correlate statistically significant with emigration countries that are less technically developed than Germany. This negative correlation was constant over all three subdomains of technological development. Finally, we unexpectedly found a positive relation between technological status of the emigration country and the intensity of routine tasks within the jobs of emigrants, which is driven by all three subdomains of technological development. Thus, H3 found only partial support here.

5. Discussion and Conclusions

Many labor markets, especially in Western countries, are currently undergoing a transformation due to technological developments. This transformation changes the demand for jobs and in turn international labor migration. To shed light onto the patterns of this so far underexplored labor migration in times of technological change, the article analyzed characteristics, geographies and possible underlying drivers of workers migrating from Germany as an exemplary case for a well-developed country. Thus, based on high-quality and unique data, this study answers the call for analyses that combine multiple perspectives to elucidate international migration decisions of individuals from highly developed countries [10,30,31].

The article adds three substantial contributions to the findings of previous research. First, we not only reflected educational profiles of German emigrants but also their occupational task structure in comparison to their non-mobile counterparts. By this, following the task approach of Autor, Levy and Murnane [2], we were able to contribute to the debate of a systematic and positive selection of international mobile or transnational professionals based on their educational status [10,63] by adding specifically demanded characteristics to this perspective. In addition to the worker's educational status, specific tasks are in demand within the international competition for talent and a skilled workforce [15,16,21]. This article suggests that individuals performing jobs with larger intensities of non-routine analytical tasks are more often internationally mobile than workers performing mainly non-routine manual, interactive or routine manual task. For political analyses dealing with labor migration flows, it would therefore be advisable to consider not only migrants' qualifications but also their occupational tasks' structure.

Second, the article reflects differences concerning the technological development between the emigration country and Germany and related agglomeration effects as a crucial contextual driver of international migration between highly developed countries [9,16]. Concerning the technological status of the emigration countries, it can be said that German emigrants tend to move to countries that are technologically more developed than Germany. These emigration flows to more developed countries are predominantly driven by better infrastructures abroad and not by discrepancies concerning know how or agility. Therefore, it would be worthwhile for policymakers to invest in promoting technical infrastructure in order to create interesting opportunities and agglomeration potential in the international competition for highly qualified and internationally demanded talents.

Third, this paper combined both analytical approaches by reflecting global migration flows through a task-based lens, revealing global discrepancies in terms of technological development levels as a crucial driver of international migration. Here, it became apparent that individuals performing tasks that require a high level of non-routine analytical work tend to move to countries, which are more technologically advanced than Germany while individuals who mainly perform non-routine manual or interactive tasks within their job seem to move to countries that are less developed in terms of technology. Moreover, and

contrary to our assumptions, workers who perform tasks with a high share of routine manual work and thus have a higher risk of being replaced by technology are also more likely to migrate to countries that are more technologically developed than Germany. However, this migration pattern is rather driven by the structure of knowledge and future readiness of the emigration countries than by the technological infrastructure. This interesting finding is again consistent with our theoretical deduction that in countries with a better technological infrastructure than in Germany the substitution probability for routine workers might be higher and these countries are thus not particularly attractive for routine workers. A better knowledge structure, i.e., better education and training programs to understand, discover and create new technologies, however, can be an important driver to maintain a place in the future labor market—especially for routine workers with a high risk of substitution. Thus, policy makers in Germany and also in countries with a similar level of technological development should invest in training activities and guidance to support and facilitate labor market transitions of individuals who mainly perform tasks with a higher risk of substitution.

6. Limitations and Future Research

Besides these substantial contributions, our study is affected by some limitations that could probably be addressed in future research. Ideally, emigration would be analyzed based on a probability sample of the German population that also includes information about a sufficient number of Germans living abroad. However, in the real world, the information about emigration is either absent of most data or the number of emigrants within existing studies does not allow sufficiently detailed subgroup-analyses [64]. By pooling a probability-based data set of non-mobiles (GSOEP) and probability-based data that explicitly cover international mobiles (GERPS), internationally mobile Germans are oversampled in our analyses. Moreover, when creating the profiles of job tasks, we rely on information for occupations performed in Germany. We assume that the composition of tasks within occupations does not differ fundamentally in other countries, but we cannot verify this precisely with our data. However, we control for occupational changes of emigrants and thus for people not performing a different job abroad than in Germany. As the survey of differentiated individual tasks is very time-consuming and the BIBB/BAuA Employment Survey holds a special position even among national data sets, there is no other alternative for applying the task approach to our research questions. Nevertheless, it would be desirable to have access to internationally comparative data on job profiles in the future, especially if further occupational changes are expected in times of technological change.

The strong aggregation of tasks also posed the risk of multicollinearity, which might to some extent result in unreliable regression coefficient estimates and misleading inferences, and thus in an underestimation of main effects [65]. With respect to the variance inflation factor (*VIF*), intensity of analytical tasks was the only remarkable covariate (see Appendix B) that may merit further investigations for potential collinearity (mainly with the control variables age and sector). While this statistical association is plausible from a theoretical point of view, we conducted, however, some further robustness checks to corroborate the validity of our results. First, all intercorrelations of predictors are below 0.5 and by this not critical [65]. Second, a sample size of more than 12,000 can be interpreted as very high and thus a further indication for the robustness against multicollinearity [65]. Third, we reflected biases due to collinearity by additionally calculating a reduced model that does not control for the suspicious variables age and sector. This theoretically less elaborated model showed the same pattern than our original model concerning the main effects but significantly less risk of collinearity (see Appendix B, Table A2; model 1d) than our initial model. However, potential confounding between occupational tasks and age and sector remain unconsidered if these items are not included in the analyses. Therefore, we decided to rely on our initial model and by this also to discharge an omitted variable bias and an increase of unobserved heterogeneity by excluding theoretically relevant covariates [66,67]. Finally, even if our study focused specifically on the emigration pat-

terns of German workers, this does not mean that Germany is affected by a brain drain, which means that most highly skilled individuals performing analytical and creative tasks leave the German labor market. On the contrary, recent studies indicate that migration flows between highly developed countries are largely temporary and circular instead of unidirectional, resulting in brain circulation rather than brain drain [10]. Accordingly, future research should also examine the re-migration of workers in times of technological change in order to assess the extent to which skills acquired abroad can benefit the German labor market.

Having in mind these limitations, our article contributes to the debate on individual and contextual drivers of international migration. Based on a unique and very up to date probability-based large-scale data set, the study elucidates factors that are beneficial to or hampering the global race for talent.

Author Contributions: Both authors contributed equally to this article. Both authors have read and agreed to the published version of the manuscript.

Funding: This research has been funded by the German Research Foundation (Deutsche Forschungsgemeinschaft DFG) under the project number 345626236. Open access funding enabled and organized by the Open Access Publication funding of University of Duisburg-Essen.

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Informed consent was obtained from all subjects involved in the study.

Data Availability Statement: GERPS data are available at the GESIS Data Archive, Cologne as study no. ZA7583. <https://doi.org/10.4232/1.13479>. GSOEP is available under: https://www.diw.de/en/diw_02.c.222829.en/access_and_ordering.html. BIBB/BAuA Employment Survey is available under: <https://www.bibb.de/de/1403.php>.

Acknowledgments: The authors would like to thank Lisa Mansfeld for her support and the three anonymous reviewers for their helpful comments.

Conflicts of Interest: The authors declare no conflict of interest.

Appendix A

Table A1. German workers' major emigration countries.

Destination Country	Percent
Switzerland (CH)	28.27
Austria (AT)	11.03
United Kingdom (GB)	8.94
United States (US)	8.83
France (FR)	5.53
Netherlands (NL)	5.27
Spain (ES)	3.37
Belgian (BE)	2.69
Sweden (SE)	2.54
Denmark (DK)	2.5
China (CN)	1.93
Norway (NO)	1.78
Australia (AU)	1.52
Italy (IT)	1.4
Canada (CA)	1.4
Ireland (IE)	1.25
Luxembourg (LU)	0.95
Japan (JP)	0.95
Poland (PL)	0.87

Table A1. Cont.

Destination Country	Percent
Singapore (SG)	0.83
Turkey (TR)	0.8
Mexico (MX)	0.76
New Zealand (NZ)	0.72
Brazil (BR)	0.57
Portugal (PT)	0.53
Czech (CZ)	0.53
United Arab Emirates (AE)	0.49
Russia (RU)	0.42
South Africa (ZA)	0.42
Israel (IL)	0.42
Finland (FI)	0.38
Romania (RO)	0.3
Greece (GR)	0.27
Chile (CL)	0.27
Thailand (TH)	0.27
Hungary (HU)	0.23
India (IN)	0.19
Indonesia (ID)	0.19
Republic of Korea (KP)	0.19
Bulgarian (BG)	0.11
Colombia (CO)	0.11
Total	100

Data: GERPS, authors' own calculations.

Appendix B. Robustness Checks

Table A2. Coefficients and average marginal effects (AME) of logistic regressions on emigration probability (extended table).

	Model 1a Education		Model 1b Tasks		Model 1c Education and Tasks		Model 1d Education and Tasks (Not Controlled for Age and Sector)	
	Coefficients	Uncentered VIF	Coefficients	Uncentered VIF	Coefficients	Uncentered VIF	Coefficients	Uncentered VIF
Education: (Ref.: Vocational Education)								
No Degree	−0.034 *** (0.007)	1.35			−0.035 *** (0.008)	1.36	−0.01 (0.009)	1.30
Higher Education	0.192 *** (0.007)	2.12			0.139 *** (0.008)	2.68	0.19 *** (0.009)	2.58
Task profiles: Intensity of . . .								
. . . nonroutine analytic tasks			0.004 *** (0.000)	17.13	0.002 *** (0.000)	20.70	0.002 *** (0.002)	10.25
. . . nonroutine manual/ interactive tasks			−0.001 *** (0.000)	7.53	−0.000 (0.000)	7.88	−0.001 *** (0.000)	5.35
. . . routine tasks			−0.002 *** (0.000)	7.30	−0.001 *** (0.000)	7.61	−0.002 *** (0.000)	5.88
Observations	12,241		12,241		12,241		12,241	
Pseudo R ² /ROC	0.517	0.934	0.488	0.926	0.530	0.938	0.318	0.869

Data: GERPS-GSOEP-BIBB/BAuA-Employment Survey, authors' own calculations. Note: Coefficients = AME; Standard errors in parentheses; * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$, Controls for respondents Age, Age2, Gender, Partnership status, Children in the Household, Migration Background, Health status, Risk attitude, and Sector are included but not displayed.

Table A3. Intercorrelation of the predictor variables.

	1	2	3	4
Vocational Education (1)	1			
Intensity of nonroutine analytic tasks (2)	0.48 ***	1		
Intensity of nonroutine manual/ interactive tasks (3)	−0.17 ***	0.15 ***	1	
Intensity of routine tasks (4)	−0.27 ***	−0.16 ***	0.24 ***	1

Data: GERPS-GSOEP-BIBB/BAuA-Employment Survey, authors' own calculations; * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

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