Firms Left Behind: Emigration and Firm Productivity[a]

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Abstract

This paper establishes a causal link between the emigration of skilled workers and firm productivity. We create a new instrument for emigration by exploiting industry-level variation in the European labor mobility regulations from 2004 to 2017. Using a new self-collected industry-level migration dataset and a large administrative firm-level panel, we show that emigration reduces firm productivity in the short term. The negative effect concerns all firms along the initial productivity distribution and is more pronounced when emigrants are positively selected. At the industry level, the effects are attenuated by firms' entry and exit dynamics. Additional evidence highlights a loss of firm-specific human capital and reduced training due to increased turnover.

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1 Introduction

"In the Lithuanian town of Panevezys, a shiny new factory [...] sits alone in the local free economic zone. The factory is unable to fill 40 of its jobs, an eighth of the total. That is not because workers in Panevezys are too picky, but because there are fewer and fewer of them."

The Economist (19 January 2017)

The emigration of skilled workers poses a challenge for many countries, not only in the developing world. As workers leave their countries of origin to follow opportunities abroad, policymakers and firm managers raise concerns about impeding skill shortages and brain drain. These concerns might translate into policies that discourage emigration, create barriers to cross-border labor mobility and hinder regional integration. However, whether there is a causal link between skilled emigration and worse firm performance in origin countries has not been established. The causality could be reverse with people leaving because of negative economic shocks in their origin, or other unobserved factors could trigger both lower firm performance and higher emigration. In addition, scarcity of high-quality emigration and firm-level data has so far constrained the empirical analyses. Yet, identifying the economic consequences of emigration at the firm level is indispensable for understanding how firms respond to the outflow of workers, how aggregate growth is shaped and for designing appropriate policies in origin countries.

This paper investigates the causal economic effects of skilled emigration.[1] Our main outcome of interest is firm productivity, measured by three different indicators: labor productivity, wage-adjusted labor productivity and total factor productivity (TFP). Especially, TFP has been considered a strong predictor of firms' survival and growth (Bartelsman et al. 2013; Bloom and Sadun 2012). Using administrative firm-level panel data from eleven Central and Eastern European countries, we show that firms in industries exposed to higher emigration of skilled workers experience a drop in all three productivity measures. A one-percent increase in labor emigration causes an approximately one percent decrease in firm productivity in the same year. Effect magnitudes are similar across various productivity measures and are

[1] As "skilled", we denote individuals with either tertiary education or a professional qualification.

present in the first two years after the increase in emigration. The negative effects on productivity are thus short-term, as both firms and workers adjust to free labor mobility.

To identify causal effects, we construct a new instrument based on industry-level variation in the European labor mobility regulations, which were in place after the 2004, 2007 and 2013 EU Eastern enlargements. For the period of seven years after the official accession of new member states (NMS), the old EU member states could apply transitional provisions and restrict access to their labor markets for NMS workers. As a result, during 2004-11 (for 2004 accession countries), 2007-14 (for 2007 accession countries), 2013-20 (for 2013 accession country), labor mobility opportunities for NMS workers within the EU varied depending on their country of origin, destination and the industry they worked in. We summarize these labor mobility regulations into a free labor mobility variable (FLM) that serves as an instrument for emigration. The instrument is plausibly exogenous to firm productivity, because detailed industry-, year- and destination-specific regulatory changes were unlikely to be influenced by firms in origin countries and were uncorrelated with other immediate accession policy changes, such as the free movement of goods or capital. Using a new, self-collected migration dataset, we show that these transitional provisions are relevant and have significant effects on the labor emigration from NMS.

Firm-level panel data allow us to account for firm heterogeneity and to explore the link between firms' characteristics and their sensitivity and adjustment to the emigration of workers. We find consistently negative effects on productivity for all firms along the initial productivity distribution. However, the reasons behind this drop differ. In response to emigration, the workforce size of lower productivity (as of pre-accession) firms shrinks, thus, we can attribute the drop in productivity to firms losing workers. The workforce size of more productive firms remains stable, however, they still experience a drop in productivity. This observation could be in line with the fact that even though more productive firms manage to replace emigrated workers, the newly hired ones are not direct substitutes to those who left, as they lack, for instance, firm-specific human capital. Once we move to the more aggregated industry level and allow for firm entry and exit, we find weaker negative effects on productivity. This can be explained by the exit of the weakest firms and missing new entries.

We investigate the mechanisms that can explain our results further. We observe that firms in industries that were more strongly exposed to the emigration of their workforce are more likely to report skill shortages, which could be linked to missing firm-specific skills and knowledge. This problem is further exacerbated by increased turnover and consequently shorter tenure due to increased emigration options. Firm-specific human capital can be acquired on the job through training or learning-by-doing. With a shorter expected tenure, both firms and individuals have fewer incentives to invest in firm-specific skill acquisition. Consistently with this, we find that the share of employees receiving job-related training is lower in industries exposed to higher emigration.

We find that the above effects are stronger when emigrants are positively selected. While we cannot directly observe the skill composition of emigrants, we use insights from the Roy-Borjas selection model (Borjas 1987; Roy 1951) to proxy for negative or positive self-selection of emigrants based on the initial differences in income dispersion between a given origin-destination country pair. We thus add an additional dimension to our free labor mobility variable and can differentiate between the effects of positively versus negatively selected emigration. We find that the negative productivity effects are significantly stronger when emigrants are positively self-selected. In addition, the results of higher skill shortages and lower job-related training are driven by positively selected emigration.

This paper relates to several strands of the literature. Most importantly, we contribute to the literature that studies the effects of emigration on origin countries by providing firm-level evidence. The brain drain literature has traditionally focused on the negative effects on origin countries through a loss of human capital (Docquier et al. 2007; Kapur and McHale 2005). However, further literature has also emphasized possible positive effects arising from higher incentives to invest in tertiary education as well as from incoming remittances and human capital gains of return migrants (Bollard et al. 2011; Docquier and Rapoport 2007).[2] Other studies on the

[2]Especially highly skilled emigrants may send large amounts of remittances and thus spur growth (Hunt 2011, 2015).

economic effects of emigration and brain drain have focused on wages (Docquier et al. 2014; Dustmann et al. 2015), aggregated economic performance (Clemens 2013; Docquier and Rapoport 2012; Freeman 2006; Grossmann and Stadelmann 2011, 2013), and firm entry and entrepreneurship (Anelli et al. 2020).[3] We contribute with an innovative firm-level analysis that provides rich evidence on the dynamics of the effect, firm heterogeneity and potential mechanisms at play.

While there is a growing migration literature that focuses on the firm as the unit of analysis, until now it has investigated the impact of *immigration*. Kerr et al. (2014), Kerr (2013), and Ottaviano and Peri (2013) encourage the firm-level approach, pointing out that it allows us to identify firm adjustment mechanisms and to address firm heterogeneity. Both are important for our understanding of how the economic effects of migration are being shaped. Kerr and Kerr (2013), Kerr et al. (2014), and Peri (2012) study the effects of immigration on firm-level outcomes in the US, and Mitaritonna et al. (2017), Ottaviano et al. (2018), and Paserman (2013) in Israel, France and the UK, respectively. They find that an increase in the supply of foreign-born workers positively affects firm productivity due to skill complementarities, faster accumulation of capital and the specialization of natives in more complex tasks.[4] By focusing on the effects of *emigration*, our research is complementary to this literature.

Some of the above mentioned mechanisms can be transferred to the case of emigration. As pointed out by a vast body of literature, skilled workers, through education, experience, and managerial skills, contribute to firm total factor productivity (Gennaioli et al. 2013; Lucas 1978; Murphy et al. 2012). The observed drop in firm productivity following emigration of skilled workers could be linked to missing skill complementarities and thus lower productivity of stayers. We illustrate one more mechanism: emigration of workers leads to the loss of firm-specific human capital that these workers had accumulated. This mechanism is in line with Jäger (2016) who observes a lack of substitutability between incumbent skilled workers and skilled workers outside the firm.

[3] Bahar et al. (2019) study the effects of return migration on export behavior. However, in our setting, return migration remains at a low level (Atoyan et al. 2016).

[4] Further firm-level studies include Dustmann and Glitz (2015) for Germany, Peri et al. (2015) for the US, and Imbert et al. (2020) for China.

Apart from migration literature, we contribute to the literature on the determinants of firm productivity (Bartelsman et al. 2013; Bloom and Sadun 2012; Bloom and Van Reenen 2007; Fox and Smeets 2011). While firm TFP is often treated as one of the core indicators of economic performance, it is also referred to as "the measure of our ignorance" (Syverson 2011). We provide empirical evidence for the channel that links firm total factor productivity to skilled emigration and, thus, emphasise the firm-specific human capital as an important determinant of TFP.

In terms of identification, we are the first to exploit industry-level variation in the EU labor mobility regulations to causally evaluate the consequences of emigration. Moreover, we constructed a novel industry-specific migration dataset covering EU and EFTA member states. There are a number of papers that show that labor mobility regulations matter for migration flows. Beine et al. (2019), Grogger and Hanson (2011), and Ortega and Peri (2013) analyze how mobility regulations have affected migration patterns. Rojas-Romagosa and Bollen (2018) show that the general introduction of the free movement of people in the EU increased migration from new to old member states. Dustmann et al. (2017) and Beerli et al. (2018) show that granting labor market access for cross-border workers in Germany and Switzerland, respectively, increased the employment of cross-border workers and affected employment and wages of the native population.

In addition, we add to the literature on the consequences of free labor mobility in the context of the EU enlargement. Following their accession to the EU, Central and Eastern European countries have experienced particularly high emigration: in 2003, the number of Central and Eastern Europeans residing in other EU countries amounted to 2.5 million; by 2018 this number reached 9 million (OECD Migration Database, Figure 1). Mayr and Peri (2009) develop a model to study the consequences of European free labor mobility on human capital in the origin countries and differentiate between brain drain and brain gain due to return migration and increased incentives to invest in education. Dustmann et al. (2015) and Elsner (2013) estimate the effects of the post-enlargement emigration on wages in Poland and Lithuania and find that wages increase for stayers. Caliendo et al. (2017) jointly study the economic effects of trade and labor market integration in the EU and argue that NMS are the largest winners from the EU enlargements. However, there have been growing concerns that the emigration of skilled workers has created severe challenges for origin countries (Kahanec 2013; OECD 2013; Zaiceva 2014). We contribute to this literature by providing nuanced micro evidence: while firms in NMS, on average, experience a drop in productivity due to the emigration of workers, this effect is short-term. We also discuss policies that could help in mitigating the negative effects.

The paper is organized as follows. The next section presents our conceptual framework. Section 3 describes the institutional setting and the data, followed by Section 4 that presents the empirical specification. Section 5 discusses the results including heterogeneous effects. Section 6 sheds light on the mechanism and Section 7 provides robustness checks. Section 8 concludes and outlines policy implications.

2 Conceptual Framework

Emigration can affect firm productivity through different channels. This section provides an overview of the links between emigration and firms' labor productivity, wage-adjusted labor productivity and TFP. While the focus of this paper is empirical, this sections provides some theoretical considerations to navigate through the empirical analysis and to identify potential mechanisms.

As emigration opportunities for the workforce increase, firms face a stronger competition in the labor market. Consequently, wages rise in the skill group of workers who are likely to emigrate (Dustmann et al. 2015). Firms can respond by substituting emigrants with workers from a different skill group and thus by changing the within-firm skill intensity or by substituting labor with capital. If firms substitute emigrated workers with capital, labor productivity (measured as value added per employee) should not substantially drop or can even increase, as labor becomes relatively more productive. Wage-adjusted labor productivity (measured as value added over personnel costs) will behave similarly, but will in addition reflect the consequences of an increase in the wage level due to more competition for scarce labor. If emigrants are positively selected and firms substitute them with less skilled workers, both labor and wage-adjusted labor productivity will decrease.

The effect on the wage-adjusted labor productivity might be attenuated as wages also reflect the quality of employees: when a firm substitutes a skilled worker with two unskilled workers, the personnel costs are not likely to double.

These substitution effects, however, will not be reflected in firm TFP (obtained by dividing output by the weighted average of labor and capital input). There are several other channels through which emigration can influence all three productivity measures. For instance, more intense competition in the factor market might induce firms to adopt better managerial practices to use scarce labor more efficiently. In this case, firm TFP will persistently increase (Bloom and Van Reenen 2007). Technology adoption will also positively influence labor and wage-adjusted labor productivity. On the contrary, if mainly skilled workers emigrate, firms might reduce their investments in new technologies, if these are complementary with skills. This will have persistent negative effects on TFP, as well as on the other two productivity measures. All three productivity measures will be also affected when workers generate positive externalities (such as spillovers on co-workers or accumulated firm-specific human capital), which are not reflected in their wages. When such workers leave, firm productivity measures will be negatively affected. Even if firms manage to hire new qualified workers, these might not be direct substitutes at least in the short term due to missing firm-specific skills. Furthermore, better emigration opportunities lead to higher turnover and shorter expected tenure of employees, which further exacerbate the problem of missing firm-specific human capital. First, employees have less time to accumulate this capital through learning-by-doing. Second, firms have lower incentives to invest in firm-specific training.

We have discussed the effects at the firm level. When we look at productivity measures aggregated at the sector level, we need to consider additional composition effects due to firm exit and entry. Emigration might induce exits of less productive firms and thus result in a positive selection of survivors. Emigration can also lead to fewer entries of new firms (Anelli et al. 2020).

3 Institutional Setting and Data

3.1 Labor Mobility Regulations in the EU

This subsection shows how the gradual opening of EU labor markets created time, country, and industry-level variation in the emigration of NMS citizens. In 2004, ten Central, Eastern and Southern European countries joined the EU: Cyprus, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Malta, Poland, Slovakia and Slovenia. While free movement of goods and capital was introduced either before or at the point of accession by all countries, free labor mobility was initially restricted by certain destination countries. Some EU15[5] countries feared an inflow of cheaper labor. Mainly motivated by political considerations, the old member states were thus allowed to unilaterally limit access to their labor markets for a period of up to seven years. These transitional provisions were applied to all NMS in the same way, except Malta and Cyprus. In 2007, Bulgaria and Romania joined the European Union, facing transitional provisions until 2014. In 2013, Croatia joined, experiencing labor market restrictions until 2020. Non-EU member states (Iceland, Liechtenstein, Norway, and Switzerland[6]), also applied transitional provisions towards new EU member states, and we thus include them in our analysis.[7]

The option to unilaterally restrict labor markets generated different labor mobility patterns within the EU. For example, for 2004-entrants, Ireland, Sweden, and the UK decided to open their labor markets immediately in 2004 without any restrictions, while other countries delayed or restricted the access to specific industries. Denmark, Greece, Spain, and Portugal, for instance, removed restrictions only in 2009. France, Belgium, the Netherlands, and Austria opened their labor markets gradually, allowing only workers in certain industries and introducing quotas. Germany kept the labor market almost completely closed until the expiration of the transitional provisions in 2011. Appendix Table A1 provides an overview of the precise opening dates for each destination (EU15+4) and origin (NMS) country.

[5]EU15 denotes old EU member states: Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, the Netherlands, Portugal, Spain, Sweden, and the United Kingdom.

[6]These four countries are denoted as +4.

[7]EU15+4 denotes all countries that applied transitional provisions.

One might argue that the restriction of a country's labor market is endogenous and related to local labor market conditions. Germany, for instance, experienced high unemployment rates during the mid-2000s and this was one of the reasons for its labor market restrictions. However, while the transitional provisions are endogenous to labor market conditions and firm productivity in the *destination* country, they are exogenous to firm outcomes in the *origin* countries. Also, restrictions needed to be the same for all NMS from a given accession year, so origin-specific exceptions were not possible.

We thus use the information on labor mobility regulations within the EU to construct an instrument for the emigration of workers to circumvent the endogeneity of emigration. We obtain the legal information from the Labor Reforms database (section on labor mobility) of the European Commission and complement it with information from national legislation.

3.2 Migration Data and Descriptive Statistics

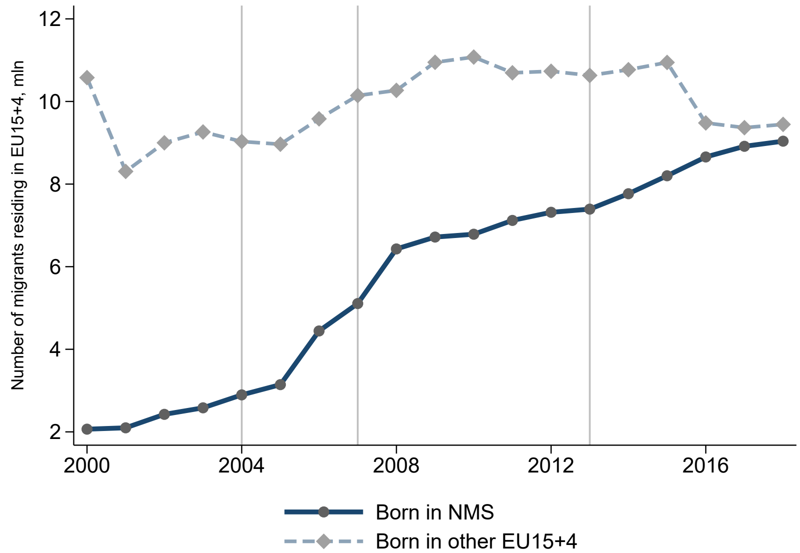
The migration data we use is self-collected industry-specific data from National Statistics offices of emigrants' destination countries (EU15+4).[8] For a few countries, it was not possible to obtain data from administrative sources, so we obtained the data from national labor force surveys or used other proxies (see Data Appendix A.3 for an overview of the precise data source by country).[9]

Figure 1 shows the stock of emigrants from NMS residing in EU15+4 countries (dark line). One can clearly see that emigration increased after the EU accession and remained at higher levels afterwards. To compare, the light line shows the stock of

[8] In general, administrative data on immigration are of better quality compared to data on emigration. First, not all emigrants officially report their departure in origin countries. Second, even if they do report it, we are not likely to observe other characteristics, such as industry of work, before the departure.

[9] Other potential migration data sources could not be used as they do not include migration data at a two-digit sector level (Global bilateral migration stock databases from the UN and the Worldbank, United Nations flow database), are only providing observations every five or ten years or do not cover all the NMS (OECD DIOC). The Eurostat Labor Force Suvey aggregates all the relevant origin countries in two groups (NMS10 for 2004-entrants and NMS3 for Bulgaria, Romania and Croatia). Moreover, as it is a survey of around five percent of the population some origin-destination-industry cells only have a few observations and are thus not reliable.

Figure 1: **Stock of EU Migrants Residing in EU15+4 Countries Before and After EU Accession**



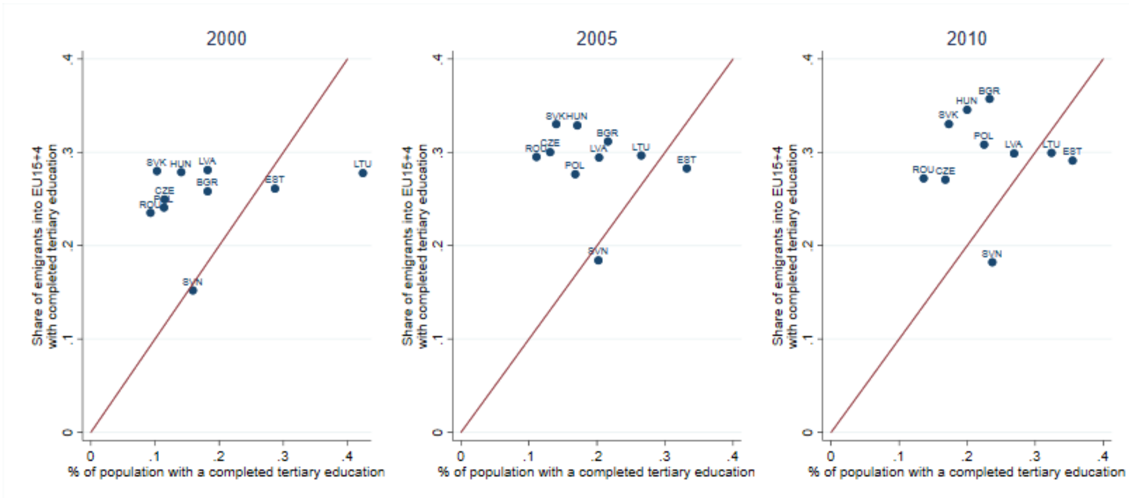
Notes: This figure shows the evolution of emigration from NMS to EU15+4 and the evolution of migration within EU15+4. The y-axis indicates the number of migrants in millions. The dark (light) line shows the number of migrants residing in the EU15+4 from the NMS (EU15+4). Vertical lines correspond to the EU enlargements of 2004, 2007 and 2013.
Source: OECD Migration (MIG) Database.

emigrants from E15+4 residing in other EU15+4 countries, which remained stable throughout the time period of interest.

These insights are in line with what has been reported in the literature. Kahanec et al. (2009), Constant (2011), and Kahanec (2013) provide descriptive evidence of increased EU migration flows following the enlargements. Using country-level data, they show that the transitional provisions influenced the movement of migrants. The UK and Ireland, for example, became the main EU destination country for Polish, Slovakian and Latvian workers. Kahanec et al. (2016) apply a difference-in-differences analysis and confirm that emigration from NMS increased with the EU accession, but its full potential was hampered by the transitional provisions.

The self-selection of emigrants can be visualised by showing differences in skill levels between NMS emigrants and the NMS general population. Figure 2 uses the IAB Brain Drain Dataset developed by Brücker et al. (2013) and shows that highly skilled individuals are overrepresented in the stock of emigrants from NMS living

Figure 2: **Education Level of NMS Emigrants as Compared to the NMS General Population**



Notes: This figure shows the share of tertiary educated emigrants in the emigrant stock of each of the NMS, contrasting it with the share of tertiary educated individuals in the respective origin country. For most NMS, the share of tertiary educated is higher among emigrants than in the general population.
Sources: IAB Brain Drain Dataset (Brücker et al. 2013), no data available after 2010. Eurostat for share of origin country population with tertiary education.

in EU15+4 as compared to the share in the remaining population of their origin countries on average. This indicates a loss of highly skilled human capital through emigration.

3.3 Firm Productivity Data and Descriptive Statistics

We obtain firm-level data from Bureau Van Dijk's ORBIS and Amadeus databases that provide standardized annual balance-sheet and profit information for European public and private companies of all sizes.[10] We work with an unbalanced panel of about 1.8 million firms located in NMS. The period covered ranges from 2000 to 2017, and there are about five annual observations for each firm on average. The sample includes companies in manufacturing, construction, retail trade and services. Apart from financial reports, the dataset provides information on firms' patents, which we use in the heterogeneity analysis. Appendix A.3.3 provides a

[10]ORBIS and Amadeus databases overlap to some extent. In our baseline specifications we included firms available either in ORBIS or Amadeus.

detailed description of the dataset.

Our sample comprises firms with at least one employee and with available data to estimate TFP. Having examined the histograms, we also noted that there are a few firms reporting untypically large figures for value added and number of employees, which is likely to be a reporting error. Therefore, in our baseline specifications we dropped these outliers (i.e. firms with value added equal to or above the 99th percentile and firms with over 100,000 workers). Our results are robust to keeping the outliers, but the estimated effects are noisier. Table 1 provides the summary statistics for firms in our sample and table A2 in the Appendix provides the summary statistics for firms from the unrestricted sample. As can be seen, firms in both samples are comparable in terms of productivity measures.

Table 1: **Summary Statistics, Firm Data**

	Mean	SD	Min	Max	N
Firm age	8.904	7.097	0	403	8929421
Turnover, thousand EUR	788.165	4276.332	0	3375883.4	11392984
Value added, thousand EUR	309.689	922.121	0	10086	11398456
Total assets, thousand EUR	717.690	10841.654	0	9217911.6	11235964
Fixed assets, thousand EUR	376.353	12374.721	0	9795480	11398456
Number of employees	13.950	110.845	1	87282	11398456
Material costs, thousand EUR	483.198	19742.034	0	65207768	11326940
Personnel costs, per employee, EUR	5982.629	17233.088	0	21867552	11398456
Total assets/L, EUR	82402.870	1.98e+06	0	4.092e+09	11235964
Fixed assets/L, EUR	40647.584	1.48e+06	0	3.280e+09	11398456
Y/L, EUR	30670.831	1.15e+05	0	10077321	11398456
Y/(WL)	12.804	360.662	0	550754.31	11388091
TFP, Levinson-Petrin	4.249	1.410	-13	15.336807	11398456
TFP, Wooldridge	3.684	1.387	-14	15.339891	11398456

Notes: This table presents summary statistics for all firm-level variables from the ORBIS/Amadeus sample used in our regression analysis. Y denotes value added, L denotes number of employees, WL denotes total personnel costs. The number of observations slightly varies due to differences in the availability of variables.

We use this firm-level data to calculate three measures of firm productivity: labor productivity, wage-adjusted labor productivity and TFP. The first measure is calculated as total value added over the number of employees. The second measure is calculated as total value added over personnel costs.[11] To obtain the third measure, we are using a semi-parametric approach as in Levinsohn and Petrin (2003) and Wooldridge (2009).[12] This method allows us to overcome the simultaneity bias

[11] The personnel costs include wages, as well as other personnel-related expenditures, such as hiring and training costs.

[12] We use the *prodest* command in Stata.

between firms' inputs and (to researchers) unobserved productivity shocks. For details, regarding the TFP calculation, we refer to the Appendix A.3.2. Other firm-level outcomes are the number of employees, personnel costs per employee and the capital-labor ratio.

3.4 Additional Data

As additional covariates, we use aggregated (two-digit NACE) industry-level data, which are available for all EU member states and are harmonized by Eurostat. The structural business statistics database contains annual indicators, such as value added, number of employees, and investment. We also use industry-level import data to control for competition that firms face. These data come from the UN Comtrade database.[13] Macroeconomic controls (GDP per capita and FDI) come from the Worldbank statistical database.

We use additional data to illustrate the mechanisms. Industry-level data (two-digit NACE) on training is coming from the EU Labor Force Survey, an annual survey conducted in all EU member states and compiled by Eurostat. We also take a measure of skill shortages from the EU Commission Business Survey, which is conducted in all EU member countries by the Directorate General for Economic and Financial Affairs (DG ECFIN). The survey addresses firms in the manufacturing, service, retail trade, and construction sectors and asks for their assessment and expectations of the business development. Among other questions, the survey's participants are asked to evaluate factors limiting their production (such as labor constraints or intense product-market competition). The EU Commission publishes information on a two-digit NACE industry level, thus the obtained measure is equal to the share of firms in a given industry reporting to be constrained by labor or competition. Table 2 provides summary statistics for all additional variables used in the estimations.

[13] The data are available at the product level, which we convert to the industry level using the NACE Revision 1 - HS 1996 correspondence table.

Table 2: **Summary Statistics, Independent Variables**

	Mean	SD	Min	Max	N
Emigrants (oit)	6101.947	21317.761	2.63	4.77e+05	15884
FLM (Free Labour Mobility) (oit)	0.080	0.122	0	1.000	15884
GDP per capita PPP, EUR (ot)	10361.370	3760.460	3010	20170.000	15884
FDI inflow mln, EUR (ot)	5032.438	9495.858	0	75107.773	15884
Value added in NMS, mln EUR (it)	6385.211	7462.687	.0395	59116.301	15048
Skill shortages in EU19, share of firms (it)	0.068	0.053	0	0.450	15884
Investment, mln EUR (oit)	186.941	365.721	0	7463.974	15048
Import share, to industry turnover (oit)	0.099	0.234	0	1.000	15048
Skill shortages in NMS, share of firms (oit)	0.121	0.146	0	1.000	8363
Product-market competition, share of firms (oit)	0.103	0.105	0	0.948	3136
Job-related training, share of workers (oit)	0.021	0.046	0	0.466	28364

Notes: The table presents summary statistics for the main independent variable (Emigrants), the baseline IV (FLM) and other covariates used in the regression analysis. We show the level of variation in parentheses: o-origin, i-industry, t-year.

4 Econometric Specification

Our baseline specification is a 2SLS regression of firm outcomes on emigration using the "Free Labor Mobility" (FLM) variable as an instrument. This captures a local average treatment effect (LATE). The FLM variable, which we describe in Section 4.2 below, summarizes the EU labor mobility regulations and quantifies the exposure of NMS firms to emigration of their workforce. For comparison, we also run OLS regressions.

4.1 OLS Specification

We begin by estimating simple OLS regressions of firm outcomes on emigration. The regression equation we estimate is the following:

$$Y_{ft} = \alpha + \beta_1 Emigrants_{oit} + \beta_2 a_{ft} + \beta_3 a_{ft}^2 + \beta_4 I_{oit-1} + \beta_5 C_{ot} + \beta_6 J_{it} + \tau_t + \nu_f + \varepsilon_{ft} \tag{1}$$

Y_{ft} are different productivity measures of a firm (f) in year (t). $Emigrants_{oit}$ denotes the number of emigrants from a given industry, origin and year. We use the contemporaneous value for the main independent variable, because by construction we observe emigrants once they are employed in the destination industry and thus we can be sure that they have left their origin some time before that. β_1 therefore captures the correlation between emigration and firm-level productivity, controlling for a set of covariates.

a_{ft} and a_{ft}^2 control for firm age. I_{oit-1} includes origin-specific industry controls such as total investment and import share. These variables account for variation in firm performance due to other shifters of labor demand within an industry of a particular country, for instance, technical change or higher competition on the product market.[14] C_{ot} is a vector of macroeconomic covariates, accounting for country-wide changes: GDP and FDI inflows. J_{it} are industry-specific controls, such as value added and skill shortages that are measured at the aggregate EU level. τ_t are time dummies that take care of common time shocks for firms in NMS. ν_f represent firm fixed effects, and ε_{ft} is the error term. Outcomes and most independent variables (except dummies and those in shares) are in natural logarithms, hence the coefficients can be interpreted as elasticities.[15] Standard errors are clustered at the origin*industry*year level.

Given that our variation is at the origin*industry*year level, we could also use origin*year and industry*year fixed effects. However, several issues arise: first, by adding these interactions, we might limit informative variation in our data; second, with additional fixed effects we introduce more variance in our estimations; third, estimations become computationally hard. We provide several robustness checks to show that our results are not driven by country- or industry-year specific shocks.

In the baseline empirical model, we consider only within-firm variation. Such a specification allows us to take care of firm unobserved time-invariant heterogeneity (as initial management ability or quality of business ideas) and other constant characteristics of a firm's location or industry-specific production technologies.

The main dependent variable is firm productivity. We further look at several other outcome variables and use the same regression equation. In particular, we are interested in the effects on total number of employees, the capital/labor ratio and the average personnel costs.

With OLS, we run into several endogeneity problems. First, we are likely to

[14]We include all origin-specific industry controls with a one year lag to limit the "bad control" problem, as the emigration of workers could have also directly affected other demand shifters.

[15]We also use an alternative transformation using inverse hyperbolic sine function, however, as we do not have negative values, nor many zeroes, the results are very close.

face reverse causality as people leave firms experiencing a negative productivity shock. Second, there are likely to be omitted variables such as a change in firm management quality, that can drive both emigration and firm productivity. Third, the main independent variable may suffer from the measurement error. We therefore move to an instrumental variable approach in the next section.

4.2 2 Stage Least Squares Specification

Higher emigration of NMS workers was triggered by the opening of the EU15+4 labor markets. We capture these changes in the EU labor mobility regulations by constructing the Free Labor Mobility (FLM) variable, which we use as an instrument for emigration in the 2SLS empirical specification. The first stage has the following form:

$$Emigrants_{oit} = \alpha + \gamma_1 FLM_{oit} + \gamma_2 I_{oit-1} + \gamma_3 C_{ot} + \gamma_4 J_{it} + \tau_t + \nu_{oi} + \phi_{oit} \quad (2)$$

Variables are denoted as above in Equation 1. We then estimate the 2SLS regressions in one step using the *ivreghdfe* command in STATA. Standard errors are clustered at the origin-industry-year level, which is the level of variation of the FLM variable.

We construct the instrument as follows. First, for each origin-industry-year observation we obtain a set of 19 dummies D_{doit}, with each dummy corresponding to one of the EU15+4 destination countries, d. A dummy takes the value of one if according to the regulation of an old EU member state, a specific industry i is open to labor migrants from a given origin country o in year t. For example, the UK completely opened up its labor market for the NMS (2004-entry) group in 2004. Therefore, UK dummies for all industries for all origin countries from this accession year equal one starting from 2004. In contrast, France held the transitional provisions for the 2004-entrants until 2008. Prior to 2008, the French government applied a special job scheme, which allowed for free labor market access only in construction, tourism, and catering. France dummies for NMS industries take a value of 0 until 2008, except for the three mentioned sectors.

One of the limitations of the legislation dummies is rather low industry-level variation. Austria, Germany, Italy, and the Netherlands, for instance, did not explicitly specify which industries are open to labor migrants from new member states, but rather allowed for special job schemes in sectors that experienced skill shortages. The dummies also do not capture different capacities of EU15+4 markets to absorb immigrants. To account for this, we multiply the legislation dummies D_{doit} by a measure of skill shortages in a given industry of a EU15+4 destination. For this, we use the share of firms (in destination industries) reporting to be constrained in production by the factor labor. These data come from the EU Commission Business Survey. This modification controls for implicit regulatory changes and for differences in labor market conditions across and within industries in the destination.[16] A possible concern with such a modification is that skill shortages in the old EU member states might be endogenous to firm productivity in NMS countries, due to, for example, common technology shocks. We control for this by including the average measure of skill shortages in a given industry and year for all EU15+4 members. Another concern is that labor demand (and thus reported shortages) could increase in EU15+4 industries, which after the EU enlargement had become more competitive relative to their NMS rivals. In this case, however, one would expect to see negative tendencies in NMS firm performance already prior to the emigration of workers. Moreover, we can account for higher product-market competition by controlling for the import share. In addition, we run a placebo test showing that our instrument is not correlated with the perceived product-market competition in NMS.

To summarize the set of 19 dummies into a single variable, we apply distance weights that reflect how strongly the opening of a particular EU15+4 labor market affects the citizens of a given new member state. We use bilateral distances between the two largest cities of each origin and destination country as a measure of proximity: the shorter the distance, the larger is the weight for a corresponding EU15+4 labor market. This assumes that labor migrants, for example, from Estonia were

[16]This allows to capture, for example, a decrease in demand for foreign labor force during and after the economic crisis in 2008-2009. At this time, many labor markets were already open for NMS citizens, but effective job possibilities were limited. De-jure, only Spain reacted to the worsening of economic conditions by reintroducing restrictions for Romanian citizens in 2011.

more sensitive to the opening of the Finnish labor market than the Portuguese one. This assumption is commonly confirmed in gravity equations for migration flows.[17]

The instrument is thus constructed in the following way:

$$FLM_{oit} = \sum_{d=1}^{19} w_{d,o} \cdot D_{doit} \tag{3}$$

FLM_{oit} is the value for one observation (origin-industry-year). D_{doit} denotes the dummy for openness of the labor market in a destination d industry i for the citizens of a given origin o in a given year, and $w_{d,o}$ denotes the weight. To ensure the comparability of different versions of FLM variables, we standardize them to be in the range [0,1], where 0 corresponds to a closed labor market and 1 to the largest exposure to emigration in our sample.

For the instrument to be valid, we need it to be relevant and to satisfy the exclusion restriction. The results for the first-stage regression are presented in the Appendix and confirm the relevance of the instrument. Table A3 shows that our first-stage results are robust to using different weights for constructing the FLM variable. However, the distance-weighted version of FLM generates the largest F-Statistics. Moreover, this table shows that the results are robust to including origin*year fixed effects and are therefore not driven by origin-specific time shocks.[18] Table A4 illustrates how our baseline FLM variable performs with different migration datasets. The largest F-Statistic is generated when we use the self-collected emigration data and complement the missing observations with proxy emigration data from OECD/Eurostat (see the note A.3 in the Appendix for the reference). Appendix Figures A1 and A2 illustrate the variation in the FLM variable across time, industries and countries.

We argue that the instrument meets the exclusion restriction, because detailed industry-, year- and destination-specific regulatory changes could not have been

[17] Alternatively to bilateral distances between the countries, we can also use distribution of immigrant stocks as of 2000 to calculate the weights. The results are very similar. We selected bilateral distances, as they generate a higher F-statistics in the first stage regression.

[18] The results are also robust to including industry*year fixed effects while controlling for GDP and FDI. When we include both origin*year and industry*year fixed effects, our estimate turns insignificant: likely we remove too much variation from the data.

influenced by firms in origin countries and were uncorrelated with other immediate accession policy changes, such as the free movement of goods or capital. Given that destination countries had to apply the same industry openings to all NMS from the same accession year, it is unlikely that a single firm (or even an industry from a certain origin) could have inserted any influence on them.

Another important assumption for our identification is that emigrated workers stay in the same industry. The industry exemptions in the transitional provisions were quite broad (often defined at a two-digit industry level), so that we consider it plausible that skilled migrants stay in the same industry. If there would be much industry switching, this would bias our estimates towards zero. While there is evidence that immigrants are typically overqualified in the destination country (Chiswick and Miller 2008, 2009; Drinkwater et al. 2009; Johnston et al. 2015; Lindley 2009; Nielsen 2011; Visintin et al. 2015), they are still likely to stay within the same sector.

5 Results

This section presents and discusses the empirical results. Regressions in Subsection 5.1, 5.2 and 5.3 include firm fixed effects and thus capture within-firm variation in outcomes as a response to the emigration of workers. Subsection 5.4 focuses on industry dynamics and thus takes into account effects stemming from the exit and entry of firms.

5.1 Productivity results

Table 3 presents our main results in column 4 - 6: we regress total factor productivity (Column 4), labor productivity (Column 5) and wage-adjusted labor productivity (Column 6) on emigration, instrumented by the Free Labor Mobility (FLM) variable.[19] Column 1-3 show respective OLS results for comparison. All outcomes and the main independent variable are in natural logarithms. The coefficients may be

[19] Our first stage estimates slightly differ from those presented in Table A3, because the latter was estimated using origin-industry-year data for all industries where we have migration data available.

Table 3: **The Effect of Emigration on Firm productivity in NMS (OLS and 2SLS)**

VARIABLES	(1) OLS TFP LP	(2) OLS Y/L	(3) OLS Y/(WL)	(4) 2SLS TFP LP	(5) 2SLS Y/L	(6) 2SLS Y/(WL)
$Emigrants_{oit}$	-0.056*	-0.052	-0.049*	-1.204**	-1.197**	-1.031***
	(0.032)	(0.033)	(0.025)	(0.468)	(0.493)	(0.368)
Age_{ft}	0.278***	0.799***	-0.138***	0.279***	0.800***	-0.137***
	(0.017)	(0.018)	(0.012)	(0.018)	(0.019)	(0.014)
Age^2_{ft}	-0.124***	-0.371***	0.004	-0.113***	-0.360***	0.013*
	(0.010)	(0.011)	(0.007)	(0.010)	(0.011)	(0.008)
$GDP\ per\ cap,\ PPP_{ot}$	0.485*	1.767***	-0.151	3.520***	4.795***	2.443**
	(0.275)	(0.290)	(0.207)	(1.275)	(1.337)	(0.990)
$FDI\ inflow_{ot}$	0.008**	0.015***	0.006**	0.007	0.013***	0.005
	(0.004)	(0.004)	(0.003)	(0.005)	(0.005)	(0.004)
$Value\ added_{it}$	0.043	0.033	0.034	0.095**	0.086*	0.079**
	(0.033)	(0.035)	(0.026)	(0.049)	(0.050)	(0.037)
$Skill\ shortages\ in\ EU19_{it}$	-0.173	-0.296	-0.561***	2.146**	2.018**	1.421*
	(0.206)	(0.224)	(0.154)	(0.918)	(0.952)	(0.739)
$Investment_{oit-1}$	0.006	0.019	0.015	-0.008	0.005	0.003
	(0.015)	(0.016)	(0.011)	(0.024)	(0.024)	(0.019)
$Import\ share_{oit-1}$	0.008	0.098	0.069	-0.276	-0.186	-0.175
	(0.057)	(0.061)	(0.043)	(0.177)	(0.181)	(0.141)
Observations	8,484,464	8,484,464	8,481,527	8,484,464	8,484,464	8,481,527
R-squared	0.554	0.655	0.640			
Clusters	11142	11142	11141	11142	11142	11141
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
First stage F-stat				21.98	21.98	21.95
FLM coefficient				0.684	0.684	0.684
FLM se				0.146	0.146	0.146

Notes: The table presents OLS (columns 1-3) and 2SLS (columns 4-6) effects of emigration on various measures of firm productivity. Column 1 and 4 show the Levinson Petrin TFP estimation method. Column 2 and 5 show results for simple labor productivity (value added/employees) and column 3 and 6 show wage-adjusted labor productivity (value added/employee costs). All specifications are estimated with firm fixed effects and time dummies. Standard errors (in parentheses) are clustered at the origin-industry-year level.
*** p<0.01, ** p<0.05, * p<0.1

interpreted as elasticity.

For an average firm in our sample, the causal effect of emigration on three different measures of productivity is negative. In the main specification, an increase in emigration of 10 percent causes a 10-12 percent decrease in firm productivity in the same year. A median annual increase in emigration of 7.86 percent as in our sample would then lead to 8.65-9.43 percent decrease in firm productivity. This is comparable with the drop in labour productivity of an average firm in our sample during the Great Recession, when we compare productivity in 2007 and 2009. As we show below (Figure 4), such sizeable effects occur in the short term (first two years following an increase in emigration) and can be linked to firms losing qualified workers. The magnitude of the results can explain why policymakers and firm managers voice concerns about brain drain in Central and Eastern Europe.

These results are confirmed when we look at the reduced form estimations (see Appendix Table A5). The reduced form abstracts from any measurement error that could arise in the migration data and shows how firm productivity changes with a higher *exposure* to emigration. A median annual increase in the FLM variable of 0.12 would lead to a 0.084 log point ($\simeq$ 8 percent) decrease in firm productivity. Given that our reduced-form estimates lead to the same qualitative conclusions as the 2SLS, for some additional (computationally-intensive) analyses below, we report results from reduced-form estimations.

There are a number of reasons why our IV estimates are stronger than our OLS results. First, OLS estimates are likely to be biased toward zero due to measurement error in the migration variable. Second, we proxy the stock of emigrants by the number of NMS-born workers employed in a given industry of an EU15+4 country. This number can increase due to the emigration of workers, but also due to other reasons: for instance, previously unemployed NMS migrants (from earlier emigration cohorts) can get employed or former NMS students who had already studied in EU15+4 enter the labor market there. While the first reason is important for firms in origin countries as they are losing workers, the other two should not substantially affect firms in origin countries. When we use our IV to predict emigration, by construction we are more likely to capture an increase due to labor emigration, as the identifying variation is generated by changes in labor mobility regulations.

5.2 Other outcomes

To understand what exactly happens at the firm level, we look at other outcomes. We do not find any significant results for any of the other outcomes for the average firm: personnel costs per employee, capital-labor ratio and number of employees. These zero effects could have two explanations. Either, different firms react differently to emigration and the average effect for all firms is zero. Or, the outcome, for instance, personnel costs per employee captures different reactions within a firm, which cancel each other out. One could imagine that wages increase on average as labor becomes more scarce. Simultaneously, firms can replace more experienced and therefore also more expensive workers with new hires that have lower wages. This could explain the null effect on personnel costs per employee. We dig deeper into this by looking at firm heterogeneity in the next section.

Table 4: **The Effect of Emigration on Other Firm Outcomes (OLS and 2SLS)**

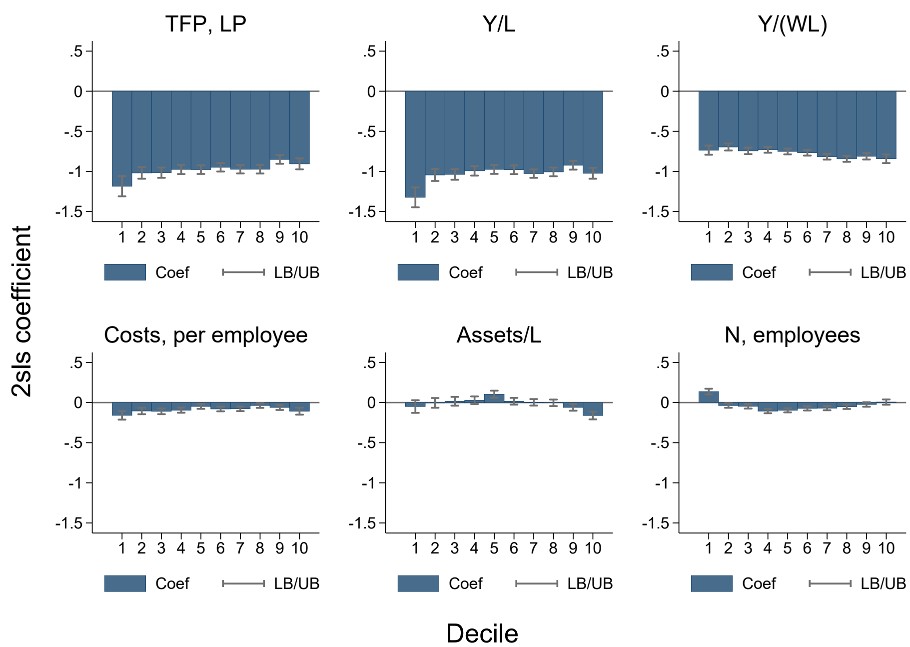
VARIABLES	(1) OLS Costs per employee	(2) OLS Assets/L	(3) OLS N employees	(4) 2SLS Costs per employee	(5) 2SLS Assets/L	(6) 2SLS N employees
$Emigrants_{oit}$	0.012*	0.024**	0.011***	0.054	0.063	-0.013
	(0.006)	(0.010)	(0.004)	(0.082)	(0.104)	(0.043)
Age_{ft}	0.884***	0.465***	0.234***	0.884***	0.465***	0.234***
	(0.012)	(0.012)	(0.006)	(0.012)	(0.012)	(0.006)
Age^2_{ft}	-0.342***	-0.176***	0.036***	-0.343***	-0.177***	0.037***
	(0.006)	(0.005)	(0.004)	(0.006)	(0.005)	(0.004)
$GDP\ per\ cap,\ PPP_{ot}$	1.993***	1.434***	-0.140***	1.882***	1.335***	-0.078
	(0.057)	(0.076)	(0.034)	(0.238)	(0.277)	(0.116)
$FDI\ inflow_{ot}$	0.007***	0.008***	-0.002***	0.007***	0.008***	-0.002***
	(0.002)	(0.001)	(0.001)	(0.002)	(0.001)	(0.001)
$Value\ added_{it}$	-0.010	-0.013	-0.017**	-0.012	-0.015	-0.016**
	(0.009)	(0.010)	(0.007)	(0.009)	(0.011)	(0.008)
$Skill\ shortages\ in\ EU19_{it}$	0.265***	-0.376**	0.653***	0.180	-0.455*	0.700***
	(0.085)	(0.168)	(0.083)	(0.160)	(0.267)	(0.128)
$Investment_{oit-1}$	0.002	0.039***	-0.007**	0.003	0.039***	-0.007**
	(0.004)	(0.005)	(0.003)	(0.004)	(0.006)	(0.003)
$Import\ share_{oit-1}$	0.012	0.194***	-0.132***	0.022	0.204***	-0.138***
	(0.022)	(0.026)	(0.019)	(0.033)	(0.038)	(0.022)
Observations	8,484,464	8,416,462	8,484,464	8,484,464	8,416,462	8,484,464
R-squared	0.808	0.830	0.881			
Clusters	11142	11140	11142	11142	11140	11142
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
First stage F-stat				21.98	21.59	21.98
FLM coefficient				0.684	0.679	0.684
FLM se				0.146	0.146	0.146

Notes: The table presents OLS (columns 1-3) and 2SLS (columns 4-6) effects of emigration on various firm outcomes. Column 1 and 4 show results for costs per employee. This includes wages and other labor costs. Column 2 and 5 show results for assets over the number of employees, which we use to measure the capital labor ratio. Column 3 and 6 show results for the number of employees. All specifications are estimated with firm fixed effects and time dummies. Standard errors (in parentheses) are clustered at the origin-industry-year level.
*** p<0.01, ** p<0.05, * p<0.1

5.3 Heterogeneity

In the main specification, we analyze the effect of higher within-EU labor mobility for the full sample of NMS firms. To check for heterogeneous effects, we repeat the estimations for different sub-samples of firms. We first look at firms in different deciles of the initial productivity distribution and study whether more productive firms behave differently than less productive firms. Then, we analyze whether innovating firms behave differently from the average firm.

Figure 3: **Results Along the Productivity Distribution**



Notes: This figure visualizes regression results for our main outcomes for firms in different productivity deciles. The sample only includes firms that existed prior to 2004 and firms are divided into productivity deciles based on their average productivity between 2000 and 2003. On the x-axes you see firm productivity deciles and on the y-axes you see the estimated coefficients from a 2sls regression with the respective outcome indicated at the top of each graph. The blue bars show the estimated coefficients for instrumented migration and the black lines show the upper and lower bounds of the 95 percent confidence interval.

Figure 3 shows the contemporaneous effect of emigration on firm productivity and other outcomes along the initial productivity distribution. To estimate the coefficients shown in this figure, the sample was split into deciles depending on a firm's productivity before the first labor market opening (we consider the average productivity of firms between 2000 and 2003). The allocation to a specific decile is done within an industry in a given country so that we do not capture certain industry- or country-specific effects. The results show that the reduction in productivity is experienced by all firms along the productivity distribution. This is why we also find statistically significant negative results for the overall sample. Costs per employee are significantly lower for all firms. One hypothesis consistent with these results is that emigrated workers have higher wages than the firm average and the firms are not able to replace them with equally qualified workers. Interestingly, results look slightly different for the other two outcomes. Firms in the second-eighth decile are those that significantly lose workers.[20] The most productive firms in the ninth and the tenth deciles are able to avoid a loss in the number of employees and adjust the capital/labor ratio, however, still lose in terms of productivity suggesting that new hires are not direct substitutes to those who left. Figure A3 in the Appendix shows the results when we lag emigration and the instrument by one year. Productivity results are again significantly negative for all firms. Yet, we see weaker effects for the most productive firms, suggesting that they can adapt faster.

Table 5 shows the results for innovating firms. We define innovating firms as firms that own at least one patent. On the one hand, these firms are in particular likely to suffer from brain drain as their highly skilled workers could be well-demanded abroad. On the other hand, innovating firms are arguably the most productive firms. As we can see, the estimated effect of emigration on firm TFP is not statistically significant and is no longer negative. At the same time, the estimated emigration coefficients for average personnel costs and capital/labor ratios suggest that these firms adjust much stronger to the increased emigration opportunities of their workforce. Innovating firms increase their personnel costs significantly more. They might be able to offer wage increases to retain workers and training to newcomers to teach them firm-specific human capital. They also seem to adapt through increasing the capital/labor ratio. These firms might also be able to provide an interesting work environment and have retention initiatives to keep their essential staff. While we focus on short-term effects, there is also evidence that innovating firms

[20]There is a somewhat puzzling effect on the number of workers for firms in the lowest deciles. We can hypothesize that this is driven by higher selection to survival for these firms: low-productivity firms are more likely to exit the market, and the fact that we still observe some of these firms in our sample several years later means that they have managed to move up.

benefit from reverse knowledge flows and increased research networks through their former employees in the longer term (Braunerhjelm et al. 2015; Fackler et al. 2020; Kaiser et al. 2015; Kerr 2008; Peri 2004).

Table 5: **The Effect of Free Labor Mobility of Workers on Firm Productivity (Firms with Patents)**

VARIABLES	(1) 2SLS TFP LP	(2) 2SLS Y/L	(3) 2SLS Y/(WL)	(4) 2SLS Costs per employee	(5) 2SLS Assets/L	(6) 2SLS N employees
$Emigrants_{oit}$	0.059	0.315	-0.189	0.360*	0.551	-0.272
	(0.270)	(0.303)	(0.181)	(0.197)	(0.340)	(0.214)
Age_{ft}	0.397***	0.591***	-0.078	0.499***	0.101	0.297***
	(0.107)	(0.110)	(0.063)	(0.066)	(0.080)	(0.068)
Age^2_{ft}	-0.090**	-0.216***	-0.006	-0.155***	-0.020	0.141***
	(0.041)	(0.043)	(0.025)	(0.026)	(0.033)	(0.028)
$GDP\ per\ cap,\ PPP_{ot}$	-0.781	-0.225	-0.317	0.639	0.285	0.148
	(0.626)	(0.704)	(0.416)	(0.468)	(0.777)	(0.520)
$FDI\ inflow_{ot}$	0.000	0.003	-0.001	0.004**	0.003	0.000
	(0.002)	(0.003)	(0.002)	(0.002)	(0.003)	(0.002)
$Value\ added_{it}$	-0.007	-0.038	0.029	-0.035	-0.057	0.071
	(0.054)	(0.062)	(0.035)	(0.040)	(0.070)	(0.045)
$Skill\ shortages\ in\ EU19_{it}$	-0.022	-0.639	0.268	-0.612	-1.234*	1.145**
	(0.609)	(0.665)	(0.388)	(0.398)	(0.730)	(0.489)
$Investment_{oit-1}$	0.008	0.001	0.023**	-0.021**	0.010	-0.001
	(0.014)	(0.016)	(0.009)	(0.010)	(0.017)	(0.012)
$Import\ share_{oit-1}$	-0.037	0.001	-0.010	0.026	0.066	0.074
	(0.083)	(0.080)	(0.041)	(0.050)	(0.076)	(0.062)
Observations	32,215	32,215	32,211	32,215	31,939	32,215
Clusters	4042	4042	4042	4042	3923	4042
First stage F-stat	6.152	6.152	6.146	6.152	5.719	6.152
FLM coefficient	0.435	0.435	0.435	0.435	0.421	0.435
FLM se	0.175	0.175	0.175	0.175	0.176	0.175
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes

Notes: The table presents 2SLS effects of emigration on various firm outcomes. The sample is restricted to firms that own at least one patent. The columns show the results for the following outcomes: Levinson and Petrin estimations of TFP, labor productivity, wage-adjusted labor productivity, costs per employee, capital labor ratio and the number of employees. All specifications are estimated with firm fixed effects and time dummies. Standard errors (in parentheses) are clustered at the origin-industry-year level.
*** p<0.01, ** p<0.05, * p<0.1

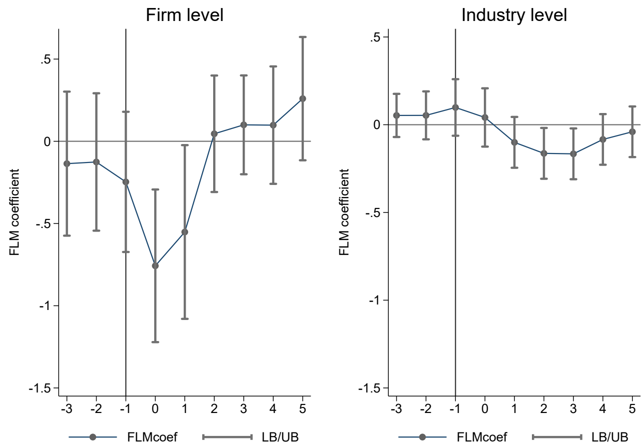
5.4 Dynamics of the Effect and Industry-level Results

So far, all results were at the firm level with the contemporaneous main independent variable and the instrument. In Figure 4 below, left panel, we show how the firm-level effects change when we consider different lags for FLM variable.[21] The strongest negative effects of emigration on firm TFP take place in the first two years after an industry's increase in the exposure to emigration. We also observe that future increases in the exposure to emigration do not have a significant effect on firm TFP. Although, one can argue for a small anticipation effect in the year just before the increase in emigration, it is rather small in magnitude and imprecisely estimated.

To investigate industry dynamics, we aggregate the data at the origin-industry-year level and set average industry-level TFP (weighted by firm employment) as our dependent variable. Therefore, our results also include effects stemming from the entry and exit of firms. Given our firm-level results, we would expect a smaller number of firms entering and a larger number of firms exiting the industries, which are exposed to emigration. If the least productive firms exit the market and do not appear in the data anymore, then we would expect negative productivity effects at the industry level to be less severe. This is indeed what we find in Figure 4, right panel. Another interesting observation is that the negative productivity effects at the industry level take place with a two year delay. This is consistent with the idea that fewer new firms are entering in $t = 0$ and $t = 1$. New entrants exhibit typically low productivity in their initial years and have a negative effect on industry productivity growth (Hyytinen and Maliranta 2013). After their initial years, they, however, show high growth, which is missing in years $t = 2$ and $t = 3$.

[21] Note that here we focus on the reduced form effects.

Figure 4: **Dynamic Effects of Emigration on TFP at the Firm and Industry Level**



Notes: The figure shows our baseline reduced-form estimates at the firm level (left) and at the industry level (right) with different time lags for the FLM variable. Controls are the same as in the baseline specification. Year and firm (left) or industry-country (right) fixed effects are included. The sample is restricted to firms with non-missing lags and forwards of FLM. Errors are clustered at the origin-industry-year level. CI at 95%.

6 The Mechanisms

6.1 The Loss of Firm-specific Human Capital

We provide additional evidence to shed more light on the mechanisms behind our main result: all three firm productivity measures drop in the short term. This cannot be exclusively explained by the substitution with lower skilled workers or by wage adjustment, as these affect (wage-adjusted) labor productivity, but not firm TFP. The complementarity between technology investments and skilled workers is also an unlikely channel, because it would have led to a more persistent decrease in TFP. Rather, one plausible mechanism is the loss of firm-specific human knowledge and skills caused by emigration. This problem is further exacerbated by firms' lower incentives to invest in training due to increased turnover.

Column 1 in Table 6 shows that firms, which experience an increase in emigration, are more likely to report skill shortages. Economists are often sceptical when hearing firms' concerns about skill shortages, as they can be alleviated by paying higher wages to attract workers.[22] In our setting, however, the reported skill short-

[22] If only the wage increase were the case, we would not have observed the drop in firm TFP.

ages also reflect the fact that even when firms manage to replace emigrated workers with new workers, those new workers are less productive, likely due to the lack of firm-specific knowledge and skills, which are not accounted for in wages.

Firm-specific human capital can be accumulated either through learning by doing or through firm-specific training. Better emigration opportunities increase worker turnover and reduce expected tenure. As the result, firms have lower incentives to invest in the training of their workers. Column 2 in Table 6 indeed shows that firms invest less in training: a one percent increase in emigration leads to a 0.024 percentage point decrease in the share of employees who receive job-related training.[23] Thus, the loss of firm-specific human capital is exacerbated by the lack of firm-specific training. Instead, workers have to learn by doing, which takes more time. This is also in line with our dynamic results, which show that the negative effects of emigration on productivity is lasting for two years and then fading out.

[23]From Table 2, this corresponds approximately to a 1.1 percent decrease in the share of trained workers.

Table 6: **Effect on Skill Shortages, Training and Number of Employees**

VARIABLES	(1) 2SLS Skill shortages	(2) 2SLS Job-related training	(3) Skill shortages	(4) Job-related training
$Emigrants_{oit}$	0.211***	-0.024***		
	(0.037)	(0.007)		
$Positive\ FLM_{oit}$			0.231***	-0.053***
			(0.041)	(0.009)
$Negative\ FLM_{oit}$			0.135***	0.005
			(0.032)	(0.004)
$GDPpercap,\ PPP_{ot}$	-0.205***	0.048***	0.186***	-0.003
	(0.072)	(0.014)	(0.024)	(0.003)
$FDI\ inflow_{ot}$	-0.002**	-0.001***	-0.003***	-0.000***
	(0.001)	(0.000)	(0.001)	(0.000)
$Value\ added_{it}$	-0.030***	0.003***	-0.011***	0.001
	(0.007)	(0.001)	(0.004)	(0.001)
$Skill\ shortages\ in\ EU19_{it}$	-0.294***	0.013	0.040	-0.006
	(0.097)	(0.011)	(0.055)	(0.009)
$Investment_{oit-1}$	0.010***	-0.000	0.015***	-0.000
	(0.003)	(0.000)	(0.002)	(0.000)
$Import\ share_{oit-1}$	0.062***	0.000	0.045***	0.005*
	(0.016)	(0.003)	(0.013)	(0.003)
Observations	7,692	9,896	7,692	9,896
First stage F-stat	70.70	74.32		
FLM coefficient	0.816	0.653		
FLM se	0.0971	0.0758		
Origin*Industry FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes

Notes: Columns 1 and 2 present 2SLS regressions of skills shortages and job-related training on instrumented emigration. Columns 3 and 4 present reduced form estimations of skill shortages and job-related training on FLM variable. Positive FLM corresponds to the exposure to positively self-selected emigration and negative FLM corresponds to the exposure to negatively self-selected emigration. All specifications are estimated with origin·industry fixed effects and time dummies. Standard errors (in parentheses) are clustered at the origin-industry-year level.
*** $p<0.01$, ** $p<0.05$, * $p<0.1$

6.2 Evidence from the Self-Selection of Emigrants

We can dig deeper into the mechanisms if we analyze the effect of differently self-selected emigrants. If the mechanism, as outlined in the previous subsection, is a loss in qualified workers and with them a part of firm-specific human capital, then countries that are affected by a positive self-selection of emigrants should be more strongly affected than countries that are facing a negative self-selection.

While we do not have data on the level of education, we can use the Roy-Borjas Model (Borjas 1987) as a tool to determine which origin-destination pairs are likely to experience positive self-selection patterns of emigrants. According to Borjas (1987) migrants are positively self-selected if income is more dispersed in the destination country.[24] We obtain data on the Gini index from the World Bank and divide origin-destination country pairs from our sample into those pairs where income in the destination is more dispersed than in the origin (positive selection cases) and those where it is not (negative selection cases). Table A4 in the Appendix shows which pairs are classified as positive selection cases and which ones are classified as negative selection ones. In line with previous literature, for instance, selection to the UK is mostly positive, whereas selection to Sweden or Germany is mostly negative.

We thus add one more dimension to the FLM variable. We aggregate all bilateral FLM dummies that correspond to country pairs with positive self-selection in the *Positive FLM variable* and FLM dummies that correspond to country pairs with negative self-selection in the *Negative FLM variable*.[25] Table 7 shows that the negative effects of emigration on all three measures of labor productivity are much stronger when emigrants are positively self-selected.[26] This result fits our story-line well because it confirms that firms experience a negative productivity shock when their qualified workers are leaving. It is also worth looking at other outcomes. Average personnel costs decrease in case of positive selection, likely because a firm loses its best and most expensive workers. If, on the contrary, a firm loses negatively selected workers, then average personnel costs increase as only lower wage workers are leaving. Equally intuitive are the differential effects on the capital-labor ratio that shows that negatively selected workers can be replaced by increasing capital, whereas positively selected (i.e. highly skilled) workers cannot.

Firms that lose positively selected workers are not changing their total number of employees. They are thus rehiring, but those newly hired workers lack firm-specific knowledge, while there are less incentives to train them due to a higher turnover. Firms losing positively selected workers are especially hit because it is more expensive to train highly skilled workers. These findings could be also in

[24] Another condition is that unobserved skill prices are sufficiently positively correlated, which is likely to be fulfilled in our context.

[25] Given that we do not have emigration data by skill group, we focus on the reduced form in this section.

[26] Our results are also robust to dropping some origin countries (Slovenia, Slovakia, Romania) who are likely to generate mostly positively or mostly negatively selected emigrants.

line with the spillover mechanism. If positively selected workers exert positive spillovers on others, then their emigration reduces positive spillovers, which results in worse TFP.

Columns 3 and 4 in Table 6 show additional results on skill shortages and training for the case of positive and negative selection. In case of a positive selection, firms are more likely (and statistically significantly so) to report skill shortages. In addition, a reduction of training is observed only in the case of positive selection. This is in line with positively selected migrants being harder to replace and more expensive to train.

Table 7: **Positive and Negative Selection, Reduced Form**

VARIABLES	(1) TFP LP	(2) Y/L	(3) Y/(WL)	(4) Costs per employee	(5) Assets/L	(6) N employees
$Positive\ FLM_{oit}$	-1.279***	-1.824***	-0.780***	-0.816***	-0.548***	0.042
	(0.253)	(0.270)	(0.196)	(0.064)	(0.075)	(0.044)
$Negative\ FLM_{oit}$	-0.686**	-0.558*	-0.657***	0.226***	0.173**	-0.019
	(0.278)	(0.295)	(0.210)	(0.054)	(0.079)	(0.032)
Age_{ft}	0.281***	0.800***	-0.134***	0.880***	0.462***	0.234***
	(0.016)	(0.018)	(0.012)	(0.012)	(0.012)	(0.006)
Age^2_{ft}	-0.123***	-0.369***	0.004	-0.341***	-0.176***	0.036***
	(0.009)	(0.010)	(0.007)	(0.006)	(0.005)	(0.004)
$GDP\ per\ cap,\ PPP_{ot}$	0.355	1.585***	-0.230	1.924***	1.423***	-0.104***
	(0.240)	(0.254)	(0.176)	(0.057)	(0.075)	(0.032)
$FDI\ inflow_{ot}$	0.008**	0.015***	0.006**	0.008***	0.008***	-0.003***
	(0.004)	(0.004)	(0.003)	(0.001)	(0.001)	(0.001)
$Value\ added_{it}$	0.041	0.031	0.033	-0.011	-0.013	-0.017**
	(0.032)	(0.034)	(0.025)	(0.007)	(0.010)	(0.007)
$Skill\ shortages\ in\ EU19_{it}$	0.616**	0.521*	0.096	0.288***	-0.346*	0.682***
	(0.252)	(0.272)	(0.190)	(0.078)	(0.179)	(0.093)
$Investment_{oit-1}$	0.012	0.025	0.020*	0.003	0.038***	-0.007**
	(0.015)	(0.016)	(0.011)	(0.004)	(0.005)	(0.003)
$Import\ share_{oit-1}$	0.058	0.153**	0.108**	0.017	0.193***	-0.135***
	(0.059)	(0.064)	(0.046)	(0.021)	(0.026)	(0.019)
Observations	8,484,464	8,484,464	8,481,527	8,484,464	8,416,462	8,484,464
R-squared	0.555	0.655	0.641	0.809	0.830	0.881
Clusters	11142	11142	11141	11142	11140	11142
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes

Notes: The table presents reduced form firm-level estimation results of higher within-EU labor mobility on various firm outcomes. The columns show the results for the following outcomes: Levinson and Petrin estimations of TFP, labor productivity, wage-adjusted labor productivity, costs per employee, capital labor ratio and the number of employees. All specifications are estimated with firm fixed effects and time dummies. Standard errors (in parentheses) are clustered at the origin-industry-year level.
*** p<0.01, ** p<0.05, * p<0.1

This section has shed some light on the mechanism. While the results are plausible, we treat them as suggestive evidence. We do not have the perfect data to disentangle the mechanisms in play. Therefore, better data (such as measures for firm-specific human capital, better proxies for the self-selection of emigrants, migration data by sector and education, or detailed training and tenure data at the firm level) and further research are necessary to analyze the mechanisms with more precision.

7 Robustness

7.1 Robust to changes in the sample composition

The results are robust to excluding certain observations. First, we exclude firms that were founded in 2004 or later. The motivation for this is that we want to exclude firms that were endogenously founded, potentially due to certain circumstances related to the EU accession. Appendix Table A6 shows the main results when the sample of firms is restricted to incumbent firms (those that existed prior to 2004). All our main results still hold. This lets us conclude that the results are not driven by new firms that behave differently.

The results are also robust to restricting the sample to the years before the financial crisis (before 2009). Emigration has been particularly strong in the early years of the opening and firms have been hit harder during the earlier years as demand and economic opportunities in EU15+4 were stronger. During the financial crisis, which hit most destinations in our sample in 2009, labor demand has decreased and therefore firms were not experiencing skill shortages as strongly as during an economic boom. This is consistent with our data. For the sample that restricts the observations to the years before 2009, we find stronger negative productivity results. All productivity indicators are negative and significant as shown in Appendix Table A7.

7.2 Robust to changes in the empirical specification

In our main specification, we use the contemporaneous values for emigration and the FLM variables. We chose this specification after observing that the effects on productivity are the largest in the year of emigration (Figure 4, left panel). Our results are robust when we lag emigration and the instrument by one year. The results are also insensitive to changing the covariates: dropping some controls; using one year lag for all the covariates; replacing GDP and FDI with origin*year fixed effects. In the latter case, our estimates remain quantitatively similar, but become less precise.

A potential alternative specification would be a staggered difference-in-differences estimation that is becoming increasingly popular. It is not possible to implement such a design in our case as the effects are only short-term. A staggered difference-in-differences design has the assumption that the treatment effects remain constant, which is not the case in our analysis.

7.3 Robustness of the first stage

There are different ways to construct the first stage. The opening of different destinations could be unweighted or weighted by distance or by the distribution of previous immigrants. Appendix Table A3 shows that first-stage estimation results are robust to various modifications of the baseline FLM and different fixed effects. Appendix Table A8 checks whether our results still hold when we do not take into account skill shortages in the destination industries. Reassuringly, the FLM coefficient is still positive and significant, however, we can also see that the relationship becomes much weaker (F-statistics drops below 10).

7.4 Placebo tests

There are two types of placebo tests we can run. The first one uses an outcome that should not be affected by changes in the FLM but also varies at the origin-industry-year level and would capture economic changes: firms' perception of the product-market competition. In the EU Business Survey, apart from skill shortages, firms also report on business challenges due to strong competition. Appendix Table A9 presents first-stage regression results with competition as a dependent variable. While for emigration all IV modifications returned statistically significant coefficients with high F-statistics, none of them is correlated with reported competition. This result reassures that the constructed IV captures labor supply shrinking due to emigration instead of other contemporaneous shocks.

An alternative placebo test regresses firms' productivity on future labor market openings. Appendix Table A10 shows that future labor market openings do not predict today's firms' productivity, which is what we would expect if the instrument is valid.

7.5 Event study

Another option to show dynamic results and to confirm that there are no pre-trends is to conduct an event study. We show the results in Appendix Figure A5. One can clearly see that there are no pre-trends and that the effect on firm productivity kicks in in year zero, which is defined as the year of the largest increase in the FLM value, i.e. the largest labor market opening for firms in a given industry. For this robustness check, we restrict our data to the time period between 2000 and 2008 because in later years the variation in FLM becomes more gradual, and it is difficult to define a single large event. Moreover, the interpretation of the effect's dynamics becomes less clear: for example, the coefficient at $x = +1$ captures the lasting effect of the largest increase at $x = 0$ *and* the effect of a subsequent opening at $x = +1$. Due to these limitations of the event study design, this is not our preferred specification and we only present it as a robustness check to argue for the absence of pre-trends before the first big increase in the exposure to emigration.

8 Conclusion and Policy Implications

Countries in Central and Eastern Europe have experienced a large emigration wave, in particular of young and skilled workers. Emigration has accelerated with the accession to the EU and remained at a high level. While emigration has in most cases economically benefited the individual migrants and the destination countries, the effects on the origin are more controversial.

This paper uses firm- and industry-level panel data to illustrate a negative causal effect of emigration on firm productivity. To overcome the endogeneity problem, we exploit the natural experiment of the EU enlargements and show that the gradual and industry-specific opening of the EU15+4 labor markets has created exogenous variation in the emigration experienced by NMS. We show that the emigration of workers results in lower productivity for firms in NMS. This effect can be observed for all firms along the initial productivity distribution. However, we find that innovating firms increase their personnel costs and capital-labor ratio and do not experience significant drops in productivity. These firms have been more successful in circumventing the loss in TFP. The negative effects on firm productivity are particularly strong in the case of positive selection of emigrants, suggesting that human capital externalities might be an important factor in explaining the result.

Our firm- and industry-level results are likely to have significant effects on aggregate growth. The IMF estimates that emigration has reduced the "average annual working-age population growth by about 0.5 – 1 percentage point since 1990 — implying that the labor supply could have been 10–20 percent greater than observed" (Atoyan et al. 2016). According to their estimates, this has led to lower annual growth rates of up to 0.9 percentage points for the most affected countries, which include Romania, Latvia and Lithuania.

Our results are important both for firms and policymakers. Being aware of the challenge helps firms to react timely and in an adequate way. Firms can benefit from investing in automation technology or active human resource strategies, focusing, for instance, on providing training and retention measures. For policymakers, the effects of emigration "are not a matter of fate, [but] to a large extent, they depend on the public policies adopted in the destination and origin countries".[27] We see three clear areas of policy interventions.

First, policymakers should enhance their efforts to increase the labor force participation of the existing population through investments in education and the en-

[27] Docquier and Rapoport (2012).

couragement of women. The prevalence of skill shortages justifies the need to invest in the skills of the local labor force and to mitigate search frictions. A skill upgrading of the local labor force can in the short term be addressed by providing specific training courses, which the state could subsidize to alleviate the burden for firms. In the long term the education system should be better adjusted to labor market needs. Knowing that those skilled people are required can justify the investment. An increase in local human capital might also happen in the long term due to increased incentives to invest in education, which rise with the prospect to emigrate (Beine et al. 2001). While a small fraction of the population will indeed emigrate, a significant fraction of well-educated workers typically remains and can help to develop the country. Another leeway is to encourage more women to participate in the labor force by improving the access and quality of childcare and abolishing disincentives to work for the second earner (Atoyan et al. 2016).

Second, policymakers could encourage return migration and immigration to increase the skilled workforce. Return migration can have various benefits for the origin country. Bahar et al. (2019) show that former Yugoslavia has benefited from return migration to boost their exports. Even if return migration is low, firms could benefit from knowledge transfers, if firms and policymakers succeed in maintaining close ties with the diaspora (Fackler et al. 2020). A few countries such as Poland and Lithuania have already recognized this potential and introduced incentives to encourage return migration. Another opportunity is to attract immigrants from other Eastern European countries, for instance Belarus or Ukraine, by facilitating labor market access. Since 2015, Poland, for instance, has provided more than half a million work and residence permits annually for workers from Ukraine and Belarus following the recent political turmoils in these countries.

Third, the fact that certain European countries benefit and others lose from free labor mobility provides a justification for EU structural and cohesion funds to be channelled to countries that bare the burden of emigrants' education expenses while not benefiting from them.

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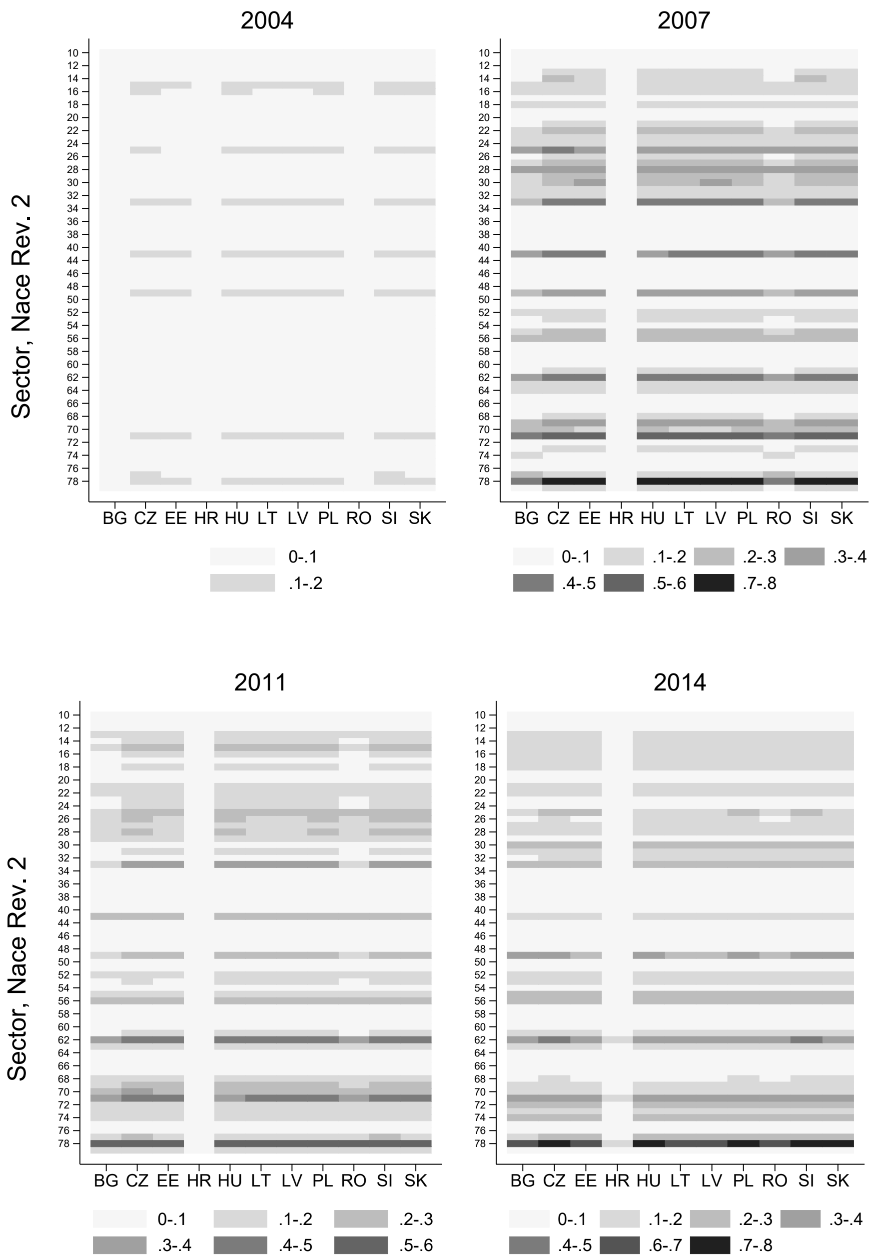
A Appendix (For Online Publication)

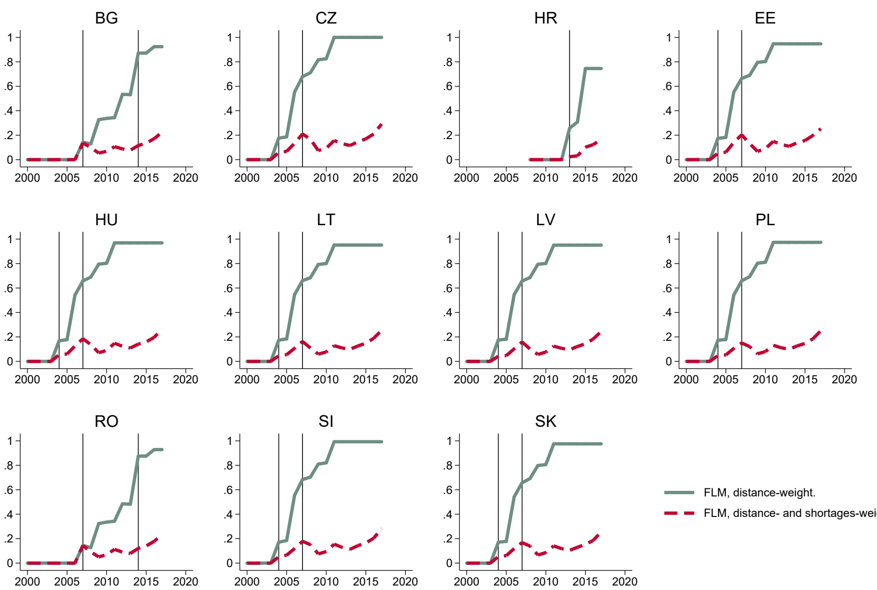
A.1 Additional Figures

Figure A1: **Variation in the Free Labor Mobility Variable**



Notes: This graph shows the variation in the FLM variable (weighted by bilateral distances and skill shortages in destination industries). We compare different industries (y-Axis) in different countries (x-Axis) in 2004, 2007, 2011, and 2014. The darker the shading, the stronger a specific industry in a specific country in a given year has been exposed to emigration of workers. The shading reflects a number between 0 and 1, where 0 means that emigration opportunities were very restricted and 1 means that emigration opportunities were the strongest in our sample. One can see, for instance, that Croatia, Bulgaria and Romania are completely in white in 2004 because those countries had not yet joined the EU and therefore emigration opportunities were restricted. In 2007, however, Romania and Bulgaria joined the EU and certain sectors in certain destination countries were open for migrants, therefore creating better emigration opportunities. Our FLM variable is weighted by skill shortages in destination industries. Because they were more prevalent for some industries in 2007 than in 2011 or 2014, the exposure to emigration for these industries appears larger in this year.

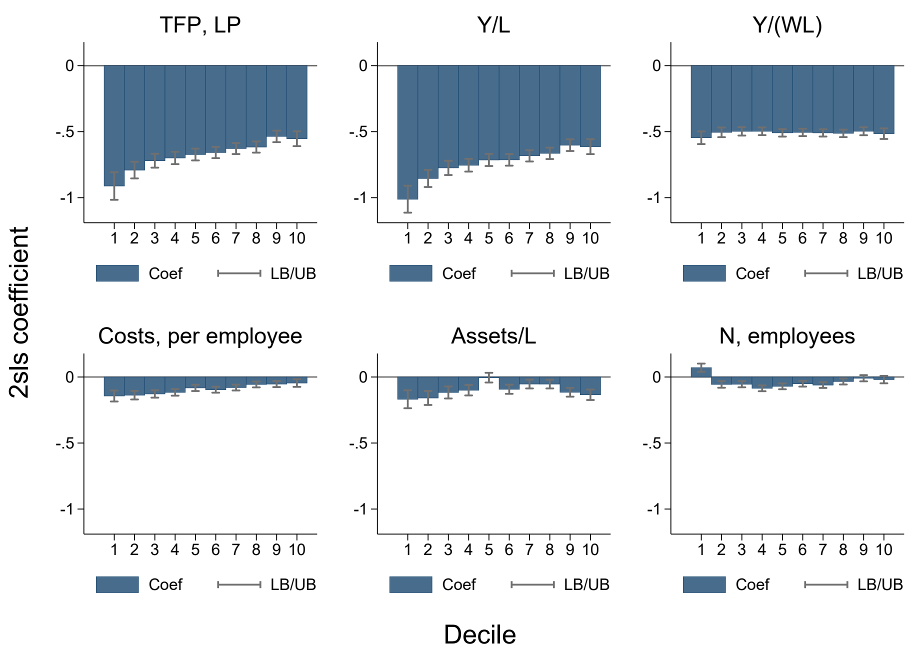
Figure A2: **Variation in the Free Labor Mobility across Countries**



Average country-level FLM, weighted by employment in origin industries.

Notes: This graph compares the variation generated by two types of FLM variable: weighted only by distances (solid line) and weighted by distances and skill shortages (dash line). Country-level aggregates are obtained by calculating an average FLM across industries (weighted by employment) for a given year and country of origin.

Figure A3: **Results Along the Productivity Distribution, One-Year Lag**



Notes: This figure visualizes regression results for our main outcomes for firms in different productivity deciles. The sample only includes firms that existed prior to 2004 and firms are divided into productivity deciles based on their average productivity between 2000 and 2003. On the x-axes you see firm productivity deciles and on the y-axes you see the estimated coefficients from a 2SLS regression with the respective outcome indicated at the top of each graph. The blue bars show the estimated coefficients for instrumented migration (both migration and the instrument are with one year lag) and the black lines show the upper and lower bounds of the 5 percent confidence interval.

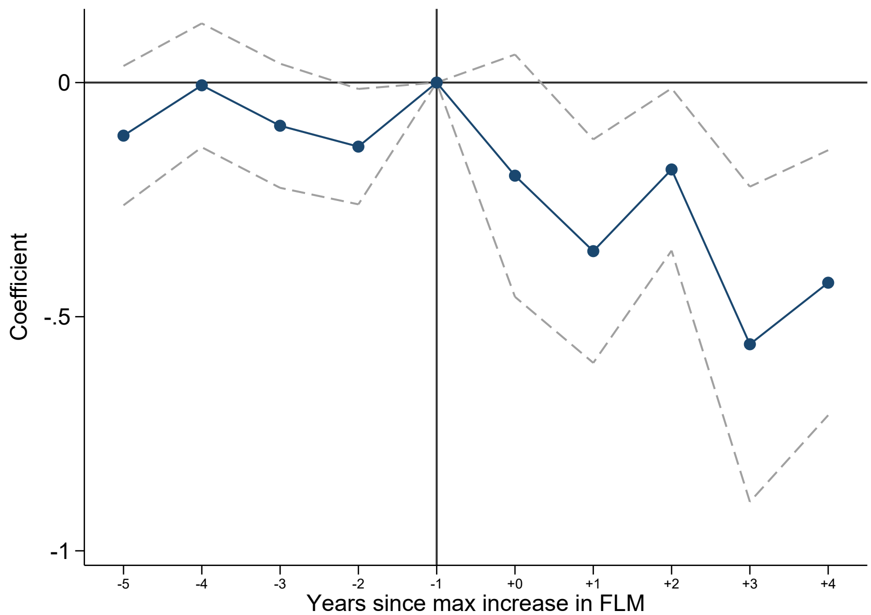
Figure A4: **Bilateral Matrix for Self-Selection**

Origin	AT	BE	CH	DE	DK	ES	FI	FR	GB
BG	-	-	-	-	-	-	-	-	+
CZ	+	+	+	+	-	+	+	+	+
EE	-	-	-	-	-	-	-	-	-
HR	-	-	+	-	-	-	-	-	+
HU	-	-	+	-	-	+	-	+	+
LT	-	-	-	-	-	-	-	-	-
LV	-	-	-	-	-	-	-	-	-
PL	-	-	-	-	-	-	-	-	-
RO	-	-	-	-	-	-	-	-	-
SI	+	+	+	+	+	+	+	+	+
SK	+	+	+	+	-	+	+	+	+

Origin	GR	IE	IS	IT	LU	NL	NO	PT	SE
BG	-	-	-	-	-	-	-	+	-
CZ	+	+	-	+	+	+	+	+	-
EE	-	-	-	-	-	-	-	+	-
HR	+	+	-	+	-	-	-	+	-
HU	+	+	-	+	+	-	-	+	-
LT	-	-	-	-	-	-	-	+	-
LV	-	-	-	-	-	-	-	+	-
PL	-	-	-	-	-	-	-	+	-
RO	-	-	-	-	-	-	-	-	-
SI	+	+	+	+	+	+	+	+	+
SK	+	+	-	+	+	+	+	+	-

Notes: We use data on country-level Gini indices (World Bank, year 2000) for NMS origins and EU15+4 destinations to proxy the self-selection of migration flows. In line with the Roy-Borjas model, migrants are positively (negatively) self-selected if inequality/the Gini index is higher (lower) in the destination compared to the origin. The rows give the origin and the columns the destination.

Figure A5: **Event Study, 2000-2008**



Notes: This figure shows the results from an event study design. As the event we define the year with the largest increase in FLM value, i.e. the largest labor market opening. We only use the time period between 2000 and 2008 because in later years the variation in FLM is more gradual and it is difficult to define a single event. This is also a limitation in this graph because it is possible that there has been a large opening in 2004 and another large opening in 2008, explaining the continuing drop also in subsequent years. The dash line represents the 95 percent confidence interval.

A.2 Additional Tables

Table A1: **Overview of the Gradual Opening of the EU15+4 Labor Markets**

Country	NMS10 (2004 entry)	NMS3 (2007 entry: Bulgaria, Romania)	NMS3 (2013 entry: Croatia)	Sectoral Exceptions
Austria	2011	2014	2020	NMS10 (2007-2010), NMS3 (2007-2013): Construction, Manufacturing of Electronics and Metals, Food and beverage services (restaurant business), other sectors with labor shortages
Belgium	2009	2014	2015	-
Denmark	2009	2009	2013	-
Finland	2006	2007	2013	-
France	2008	2014	2015	NMS10 (2005-2007), NMS3 (2007-2013): Agriculture, Construction, Accommodation and food services (tourism and catering), other sectors with labor shortages
Germany	2011	2014	2015	NMS10 (2004-2010), NMS3 (2007-2013): sectors with labor shortages
Greece	2006	2009	2015	-
Iceland	2006	2012	2015	-
Ireland	2004	2012	2013	-
Italy	2006	2012	2015	NMS10 (2004-2005): sectors with labor shortages; NMS3 (2007-2011): Agriculture, Construction, Engineering, Accommodation and food services (tourism and catering), Domestic work and care services, other sectors with labor shortages; Occupations: Managerial and professional occupations
Luxembourg	2008	2014	2015	NMS3 (2007 - 2013): Agriculture, Viticulture, Accommodation and food services (tourism and catering)
Netherlands	2007	2014	2018	NMS10 (2004-2006), NMS3 (2007-2013): International transport, Inland shipping, Health, Slaugther-house/meat-packaging, other sectors with labor shortages
Norway	2009	2012	2014	NMS10 (2004-2008), NMS3 (2007-2011): sectors with labor shortages
Portugal	2006	2009	2013	-
Spain	2006	2009	2015	Reintroduction of restrictions for Romanians: 11/08/2011 - 31/12/2013
Sweden	2004	2007	2013	-
Switzerland	2011	2016	2024 (tbc)	-
United Kingdom	2004	2014	2018	NMS3 (2007-2013): Agriculture, Food manufacturing

Notes: Column 2 shows the year of the labor market opening of the respective country for NMS8 countries, column 3 shows the year of the labor market opening of the respective country for Bulgaria and Romania and column 4 for Croatia. Column 5 shows, which industries were exempt from restrictions before the transitional provisions for the entire labor market.
Source: Compiled by the authors using the LABREF database (European Commission) and national legislations.

Table A2: **Summary Statistics, Unrestricted Firm Data**

	Mean	SD	Min	Max	N
Firm age	7.694	6.754	0	652	39942622
Turnover, thousand EUR	1335.461	1.95e+05	0	9.452e+08	24572914
Value added, thousand EUR	805.557	1.40e+05	0	5.159e+08	13970786
Total assets, thousand EUR	1595.088	2.71e+05	0	1.199e+09	20461502
Fixed assets, thousand EUR	926.599	1.25e+05	0	5.336e+08	20667258
Number of employees	13.079	230.719	0	401427	32162784
Material costs, thousand EUR	970.942	1.17e+05	0	4.294e+08	14611593
Personnel costs, per employee, EUR	6216.815	2.37e+05	0	8.099e+08	14557943
Total assets/L, EUR	1.23e+05	1.96e+07	0	7.187e+10	16251358
Fixed assets/L, EUR	66392.303	7.25e+06	0	1.712e+10	16440313
Y/L, EUR	39108.917	6.91e+06	0	2.377e+10	12083682
Y/(WL)	14.133	569.566	0	1126350	12339550

Notes: The table presents summary statistics for all firm-level variables from an ORBIS/Amadeus sample that is not restricted by the availability of TFP data and that does not drop outliers based on the reported value added.

Table A3: **First Stage Regressions**

VARIABLES	(1) FLM dummy	(2) FLM dummy	(3) FLM dummy distance w.	(4) FLM dummy distance w.	(5) FLM dummy migration w.	(6) FLM dummy migration w.
FLM_{oit}	0.792***	0.727***	0.843***	0.789***	0.691***	0.653***
	(0.109)	(0.106)	(0.115)	(0.111)	(0.109)	(0.104)
$GDPpercap, PPP_{ot}$	2.451***		2.457***		2.444***	
	(0.133)		(0.132)		(0.133)	
$FDI\ inflow_{ot}$	-0.006**		-0.006**		-0.006**	
	(0.003)		(0.003)		(0.003)	
$Value\ added_{it}$	0.036**	0.030*	0.036**	0.030*	0.037**	0.032*
	(0.017)	(0.017)	(0.017)	(0.017)	(0.017)	(0.017)
$Skill\ shortages\ in\ EU19_{it}$	1.387***	1.447***	1.376***	1.426***	1.311***	1.358***
	(0.188)	(0.163)	(0.188)	(0.163)	(0.184)	(0.163)
$Investment_{oit-1}$	0.020**	0.021**	0.020**	0.021**	0.020**	0.021**
	(0.010)	(0.010)	(0.010)	(0.010)	(0.010)	(0.010)
$Import\ share_{oit-1}$	-0.191**	-0.189***	-0.190**	-0.188***	-0.177**	-0.175**
	(0.075)	(0.069)	(0.075)	(0.069)	(0.076)	(0.070)
Observations	14,212	14,212	14,212	14,212	14,212	14,212
R-squared	0.946	0.954	0.946	0.954	0.946	0.954
F-stat	52.84	47.13	54.06	50.28	40.04	39.14
Origin*Industry FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes		Yes		Yes	
Origin*Year FE		Yes		Yes		Yes

Notes: The table presents the effect of higher within-EU labor mobility on emigration from NMS. Dependent variable: Number of emigrants (log). FLM - Free Labor Mobility variable. FLM dummy - sum of bilateral dummies, weighted by skill shortages in destination industries. FLM dummy distance w. - FLM dummy, but in addition uses distance as weights. FLM dummy migration w. - FLM dummy, but in addition uses previous distribution of emigration stocks as weights. Specifications 2, 4, and 6 check for robustness to including origin*year fixed effects. Standard errors (in parentheses) are clustered at the origin-industry-year level.
*** p<0.01, ** p<0.05, * p<0.1

Table A4: **First Stage with Different Migration Data**

VARIABLES	(1) Emigrants comb. dataset	(2) Emigrants only nat. offices	(3) Emigrants only OECD/Eurostat
FLM_{oit}	0.843***	0.734***	0.658***
	(0.115)	(0.194)	(0.133)
$GDPpercap,\ PPP_{ot}$	2.457***	4.577***	2.332***
	(0.132)	(0.238)	(0.148)
$FDI\ inflow_{ot}$	-0.006**	-0.004	-0.011***
	(0.003)	(0.004)	(0.003)
$Value\ added_{it}$	0.036**	0.073**	0.026
	(0.017)	(0.031)	(0.019)
$Skill\ shortages\ in\ EU19_{it}$	1.376***	-0.083	1.026***
	(0.188)	(0.387)	(0.219)
$Investment_{oit-1}$	0.020**	0.008	0.038***
	(0.010)	(0.018)	(0.012)
$Import\ share_{oit-1}$	-0.190**	-0.307**	-0.193**
	(0.075)	(0.133)	(0.077)
Observations	14,212	14,212	14,212
R-squared	0.946	0.864	0.945
F-stat	54.06	14.31	24.67
Origin*Industry FE	Yes	Yes	Yes
Year FE	Yes	Yes	Yes

Notes: The table compares the performance of the baseline FLM variable (weighted by skill shortages and bilateral distances) with different migration datasets. (1) uses our self-collected data from the national statistical offices, where the missing observations were complemented by proxy OECD/Eurostat data. (2) uses only the self-collected data from the national statistical offices. (3) uses only the proxy OECD/Eurostat data.

Table A5: **Reduced Form Results**

VARIABLES	(1) TFP LP	(2) TFP WRDG	(3) Y/L	(4) Y/(WL)	(5) Costs per employee	(6) Assets/L	(7) N employees
FLM_{oit}	-0.824***	-0.826***	-0.820***	-0.705***	0.037	0.043	-0.009
	(0.277)	(0.276)	(0.296)	(0.210)	(0.056)	(0.072)	(0.029)
Age_{ft}	0.283***	0.211***	0.804***	-0.133***	0.884***	0.464***	0.234***
	(0.016)	(0.016)	(0.018)	(0.012)	(0.012)	(0.012)	(0.006)
Age^2_{ft}	-0.123***	-0.105***	-0.371***	0.004	-0.342***	-0.176***	0.036***
	(0.009)	(0.009)	(0.010)	(0.007)	(0.006)	(0.005)	(0.004)
$GDP\ per\ cap,\ PPP_{ot}$	0.409*	0.294	1.701***	-0.220	2.021***	1.492***	-0.110***
	(0.232)	(0.231)	(0.245)	(0.171)	(0.054)	(0.073)	(0.031)
$FDI\ inflow_{ot}$	0.007**	0.007**	0.014***	0.006**	0.007***	0.008***	-0.002***
	(0.004)	(0.004)	(0.004)	(0.003)	(0.002)	(0.001)	(0.001)
$Value\ added_{it}$	0.042	0.044	0.033	0.033	-0.010	-0.012	-0.017**
	(0.033)	(0.032)	(0.034)	(0.025)	(0.009)	(0.010)	(0.007)
$Skill\ shortages\ in\ EU19_{it}$	0.595**	0.531**	0.475*	0.092	0.250***	-0.374**	0.684***
	(0.255)	(0.254)	(0.279)	(0.191)	(0.085)	(0.184)	(0.093)
$Investment_{oit-1}$	0.011	0.012	0.024	0.020*	0.002	0.038***	-0.007**
	(0.015)	(0.015)	(0.016)	(0.011)	(0.004)	(0.005)	(0.003)
$Import\ share_{oit-1}$	0.053	0.061	0.142**	0.107**	0.007	0.187***	-0.135***
	(0.058)	(0.058)	(0.063)	(0.045)	(0.022)	(0.026)	(0.019)
Observations	8,484,464	8,484,464	8,484,464	8,481,527	8,484,464	8,416,462	8,484,464
R-squared	0.555	0.538	0.655	0.641	0.808	0.830	0.881
Clusters	11142	11142	11142	11141	11142	11140	11142
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Notes: The table presents reduced form effects of higher within-EU labor mobility on various firm outcomes. The columns show the results for the following outcomes: Levinson and Petrin estimations of TFP, Wooldridge estimations of TFP, labor productivity, wage-adjusted labor productivity, costs per employee, capital labor ratio and the number of employees. All specifications are estimated with firm fixed effects and time dummies. Standard errors (in parentheses) are clustered at the origin-industry-year level.
*** p<0.01, ** p<0.05, * p<0.1

Table A6: **Regression Restricted to Incumbents**

VARIABLES	(1) 2SLS TFP LP	(2) 2SLS Y/L	(3) 2SLS Y/(WL)	(4) 2SLS Costs per employee	(5) 2SLS Assets/L	(6) 2SLS N employees
$Emigrants_{oit}$	-0.936***	-0.980***	-0.746***	-0.093	0.023	-0.086**
	(0.351)	(0.376)	(0.270)	(0.073)	(0.088)	(0.043)
Age_{ft}	0.125***	0.576***	-0.215***	0.776***	0.327***	0.209***
	(0.028)	(0.039)	(0.028)	(0.046)	(0.023)	(0.018)
Age^2_{ft}	-0.067***	-0.256***	0.011	-0.247***	-0.142***	0.049***
	(0.011)	(0.016)	(0.010)	(0.016)	(0.008)	(0.008)
$GDP\ per\ cap,\ PPP_{ot}$	3.201***	4.792***	1.993**	2.475***	1.773***	0.103
	(1.099)	(1.166)	(0.839)	(0.238)	(0.274)	(0.134)
$FDI\ inflow_{ot}$	0.044***	0.048***	0.031***	0.006***	0.011***	0.003*
	(0.010)	(0.010)	(0.008)	(0.002)	(0.003)	(0.002)
$Value\ added_{it}$	0.073*	0.065	0.050	-0.000	-0.029**	-0.005
	(0.042)	(0.044)	(0.032)	(0.009)	(0.012)	(0.009)
$Skill\ shortages\ in\ EU19_{it}$	2.175**	2.065**	1.270*	0.516***	-0.468	1.168***
	(0.945)	(1.007)	(0.739)	(0.190)	(0.307)	(0.185)
$Investment_{oit-1}$	0.011	0.025	0.019	0.005	0.044***	-0.012***
	(0.020)	(0.021)	(0.015)	(0.005)	(0.006)	(0.004)
$Import\ share_{oit-1}$	-0.135	-0.036	-0.053	0.018	0.213***	-0.186***
	(0.130)	(0.137)	(0.099)	(0.032)	(0.035)	(0.028)
Observations	3,761,824	3,761,824	3,760,365	3,761,824	3,726,814	3,761,824
Clusters	10323	10323	10322	10323	10321	10323
First stage F-stat	33.50	33.50	33.45	33.50	33.02	33.50
FLM coefficient	0.951	0.951	0.950	0.951	0.945	0.951
FLM se	0.164	0.164	0.164	0.164	0.164	0.164
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes

Notes: The table presents 2SLS effects of higher within-EU labor mobility on various firm outcomes. The sample is restricted to firms that existed before 2004. The columns show the results for the following outcomes: Levinson and Petrin estimations of TFP, labor productivity, wage-adjusted labor productivity, costs per employee, capital labor ratio and the number of employees. All specifications are estimated with firm fixed effects and time dummies. Standard errors (in parentheses) are clustered at the origin-industry-year level.
*** p<0.01, ** p<0.05, * p<0.1

Table A7: **Regression Restricted to Before 2009**

VARIABLES	(1) 2SLS TFP LP	(2) 2SLS Y/L	(3) 2SLS Y/(WL)	(4) 2SLS Costs per employee	(5) 2SLS Assets/L	(6) 2SLS N employees
$Emigrants_{oit}$	-1.482**	-1.497**	-1.264**	-0.000	0.112	0.033
	(0.658)	(0.701)	(0.530)	(0.097)	(0.100)	(0.033)
Age_{ft}	0.243***	0.888***	-0.262***	1.095***	0.429***	0.238***
	(0.046)	(0.050)	(0.035)	(0.025)	(0.021)	(0.009)
Age^2_{ft}	-0.196***	-0.530***	0.005	-0.478***	-0.190***	0.065***
	(0.021)	(0.024)	(0.017)	(0.018)	(0.009)	(0.007)
$GDP\ per\ cap,\ PPP_{ot}$	6.860***	8.786***	5.059***	2.699***	2.108***	-0.244**
	(1.724)	(1.824)	(1.395)	(0.269)	(0.274)	(0.099)
$FDI\ inflow_{ot}$	-0.051	-0.013	-0.059	0.051***	0.109***	-0.006
	(0.066)	(0.069)	(0.055)	(0.011)	(0.013)	(0.005)
$Value\ added_{it}$	0.025	0.028	0.017	-0.000	-0.010	-0.020**
	(0.070)	(0.074)	(0.058)	(0.010)	(0.014)	(0.008)
$Skill\ shortages\ in\ EU19_{it}$	3.777*	3.737*	2.959*	0.305	-0.236	0.675***
	(2.008)	(2.096)	(1.659)	(0.267)	(0.325)	(0.163)
$Investment_{oit-1}$	0.006	0.023	0.003	0.022***	0.045***	0.001
	(0.049)	(0.050)	(0.040)	(0.006)	(0.008)	(0.004)
$Import\ share_{oit-1}$	-0.440	-0.359	-0.365	0.072	0.170***	-0.078***
	(0.365)	(0.374)	(0.304)	(0.045)	(0.050)	(0.024)
Observations	3,032,906	3,032,906	3,031,171	3,032,906	3,013,497	3,032,906
Clusters	5235	5235	5234	5235	5235	5235
First stage F-stat	17.39	17.39	17.34	17.39	17.24	17.39
FLM coefficient	0.956	0.956	0.955	0.956	0.954	0.956
FLM se	0.229	0.229	0.229	0.229	0.230	0.229
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes

Notes: The table presents 2SLS effects of higher within-EU labor mobility on various firm outcomes. The sample is restricted to the years before 2009. The columns show the results for the following outcomes: Levinson and Petrin estimations of TFP, labor productivity, wage-adjusted labor productivity, costs per employee, capital labor ratio and the number of employees. All specifications are estimated with firm fixed effects and time dummies. Standard errors (in parentheses) are clustered at the origin-industry-year level.
*** p<0.01, ** p<0.05, * p<0.1

Table A8: **Robustness: First Stage, Not Weighted by Skill Shortages**

VARIABLES	(1) FLM dummy	(2) FLM dummy	(3) FLM dummy distance w.	(4) FLM dummy distance w.	(5) FLM dummy migration w.	(6) FLM dummy migration w.
FLM_{oit}	0.122***	0.627	0.103**	0.588	0.032	-0.019
	(0.042)	(0.472)	(0.045)	(0.471)	(0.034)	(0.206)
$GDPpercap,\ PPP_{ot}$	2.465***		2.477***		2.486***	
	(0.134)		(0.134)		(0.135)	
$FDI\ inflow_{ot}$	-0.006**		-0.006**		-0.007**	
	(0.003)		(0.003)		(0.003)	
$Value\ added_{it}$	0.044**	0.039**	0.044**	0.039**	0.044**	0.039**
	(0.018)	(0.018)	(0.018)	(0.018)	(0.018)	(0.018)
$Skill\ shortages\ in\ EU19_{it}$	2.001***	2.010***	2.001***	2.010***	2.000***	2.011***
	(0.189)	(0.164)	(0.189)	(0.164)	(0.190)	(0.163)
$Investment_{oit-1}$	0.020**	0.020**	0.020**	0.020**	0.020**	0.021**
	(0.010)	(0.010)	(0.010)	(0.010)	(0.010)	(0.010)
$Import\ share_{oit-1}$	-0.164**	-0.164**	-0.164**	-0.164**	-0.163**	-0.163**
	(0.076)	(0.070)	(0.076)	(0.070)	(0.076)	(0.070)
Observations	14,212	14,212	14,212	14,212	14,212	14,212
R-squared	0.945	0.954	0.945	0.954	0.945	0.954
F-stat	8.467	1.765	5.199	1.559	0.876	0.00832
Origin*Industry FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes		Yes		Yes	
Origin*Year FE		Yes		Yes		Yes

Notes: The table presents the first stage for different versions of the instrument (not weighted by skill shortages). Column 1 and 2 show the unweighted version of the instrument. In column 3 and 4, we weigh a country pair by distance and in column 5 and 6 we weigh it by the bilateral stock of migrants. All specifications are estimated with origin·industry fixed effects and year or origin·year fixed effects. Standard errors (in parentheses) are clustered at the origin-industry-year level.
*** p<0.01, ** p<0.05, * p<0.1

Table A9: **Robustness: First Stage with Competition**

VARIABLES	(1) FLM dummy	(2) FLM dummy	(3) FLM dummy distance w.	(4) FLM dummy distance w.	(5) FLM dummy migration w.	(6) FLM dummy migration w.
FLM_{oit}	0.068	0.087	0.070	0.091	0.071	0.109
	(0.053)	(0.058)	(0.056)	(0.061)	(0.075)	(0.079)
$GDPpercap,\ PPP_{ot}$	-0.186***		-0.185***		-0.185***	
	(0.044)		(0.044)		(0.045)	
$FDI\ inflow_{ot}$	-0.000		-0.000		-0.000	
	(0.001)		(0.001)		(0.001)	
$Value\ added_{it}$	0.004	0.008	0.004	0.008	0.005	0.009
	(0.013)	(0.013)	(0.013)	(0.013)	(0.013)	(0.013)
$Skill\ shortages\ in\ EU19_{it}$	-0.258*	-0.285**	-0.256*	-0.283**	-0.254*	-0.302**
	(0.138)	(0.136)	(0.139)	(0.136)	(0.150)	(0.145)
$Investment_{oit-1}$	0.003	0.000	0.003	0.000	0.002	0.000
	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)
$Import\ share_{oit-1}$	0.005	0.017	0.005	0.017	0.007	0.019
	(0.022)	(0.021)	(0.022)	(0.021)	(0.022)	(0.021)
Observations	2,896	2,896	2,896	2,896	2,896	2,896
R-squared	0.367	0.411	0.367	0.411	0.367	0.412
F-stat	1.649	2.285	1.548	2.210	0.893	1.897
Origin*Industry FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes		Yes		Yes	
Origin*Year FE		Yes		Yes		Yes

Notes: Dependent variable - share of firms reporting intense product-market competition as an obstacle to doing business. FLM dummy - sum of bilateral dummies, weighted by skill shortages in destination industries. FLM dummy distance w. - FLM dummy, but in addition uses distance as weights. FLM dummy migration w. - FLM dummy, but in addition uses previous distribution of emigration stocks as weights. All specifications are estimated with origin·industry fixed effects and year or origin·year fixed effects. Standard errors (in parentheses) are clustered at the origin-industry-year level.
*** p<0.01, ** p<0.05, * p<0.1

Table A10: **Robustness: Using Forward FLM Variable**

VARIABLES	(1) TFP LP	(2) TFP WRDG	(3) Y/L	(4) Y/(WL)
FLM_{oit+1}	-0.032	-0.037	-0.025	-0.075
	(0.206)	(0.205)	(0.213)	(0.158)
Age_{ft}	0.341***	0.263***	0.885***	-0.127***
	(0.016)	(0.016)	(0.017)	(0.012)
Age^2_{ft}	-0.135***	-0.115***	-0.394***	-0.000
	(0.009)	(0.009)	(0.010)	(0.007)
$GDP\ per\ cap,\ PPP_{ot}$	0.161	0.039	1.454***	-0.457***
	(0.229)	(0.228)	(0.241)	(0.176)
$FDI\ inflow_{ot}$	0.010***	0.009***	0.018***	0.007**
	(0.004)	(0.004)	(0.003)	(0.003)
$Value\ added_{it}$	0.032	0.034	0.029	0.028
	(0.032)	(0.032)	(0.034)	(0.027)
$Skill\ shortages\ in\ EU19_{it}$	-0.254	-0.308	-0.359	-0.551***
	(0.214)	(0.213)	(0.227)	(0.168)
$Investment_{oit-1}$	0.019	0.019	0.033**	0.023**
	(0.014)	(0.014)	(0.015)	(0.011)
$Import\ share_{oit-1}$	0.078	0.087*	0.180***	0.127***
	(0.049)	(0.049)	(0.053)	(0.040)
Observations	6,635,500	6,635,500	6,635,500	6,634,510
R-squared	0.597	0.580	0.694	0.676
Clusters	10574	10574	10574	10573
Firm FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes

Notes: The table presents reduced-form effects of higher within-EU labor mobility on various firm productivity measures. The sample is constructed in a way that we regress future labor market openings on current productivity. This robustness check shows that future labor market openings do not predict firm productivity, which is reassuring. The columns show the results for the following outcomes: Levinson and Petrin estimations of TFP, Wooldridge estimations of TFP, labor productivity, and wage-adjusted labor productivity. All specifications are estimated with firm fixed effects and time dummies. Standard errors (in parentheses) are clustered at the origin-industry-year level.
*** p<0.01, ** p<0.05, * p<0.1

A.3 Data Appendix

A.3.1 Overview of Migration Data

Data collected from the National Statistical Offices

Austria

Main Association of Austrian Social Security Institutions: posteingang.allgemein@hvb.sozvers.at
Source: Austrian social security data, universe of workers who are subject to social security contributions
Migrants identified by nationality
Available for 2000-2016

Belgium

1)

Belgian statistical office: demos@economie.fgov.be
Source: Statbel (Direction générale Statistique - Statistics Belgium), Labour Force Survey
Migrants identified by country of birth
Available for 2000-2017

2)

Belgian crossroad bank for social security : https://www.ksz-bcss.fgov.be/en
Source: administrative data from the Belgian national registry data, universe of workers subject to social security contributions
Migrants identified by country of birth
Available for 2008-2017

Finland

Statistics Finland, Population and Social Statistics: www.stat.fi
Source: Universe of workers in Finland based on a compilation from Statistics using different administrative and statistical data
Migrants identified by country of birth
Available for 2000-2016

France

Réseau Quetelet, ADISP https://quetelet.casd.eu
Source: Population census https://www.insee.fr/fr/information/1303686
Migrants identified by country of birth
Available for 1999, 2006, 2011, 2016 (possible to obtain only for every five years)

Norway

Statistics Norway okonomi@ssb.no
Source: NAV's Employee Register (Aa Register) and A-ordninge, data from coordinated digital collection of employment, income and tax deductions for the Tax Administration, NAV and Statistics Norway
Migrants identified by country of birth
Available for 2000-2018

Sweden

Statistics Sweden, Microdata Unit: www.scb.se
Source: administrative registers
Migrants identified by country of birth
Available for 2000-2016

Spain

National Statistics Institute, INE, https://www.ine.es/en/index.htm
Source: Labor Force Survey
Migrants identified by nationality
Available for 2006, 2008, 2010, 2012, 2014, 2016

Switzerland

Federal Statistical Office, https://www.bfs.admin.ch/bfs/en/home.html
Source: Swiss Labour Force Survey (SAKE)
Migrants identified by country of birth
Available for 2000-2018

United Kingdom

Office for national statistics https://www.ons.gov.uk
Source: Annual Population Survey data
Migrants identified by country of birth
Available from 2000 to 2018; the dataset from our request is published here
Link to data

Proxy data for missing migration data

We used Eurostat data on migration stocks at year, destination and origin (country of birth) level (migr_pop3ctb). For missing data, we used another migration dataset at year, destination, and country of citizenship level (migr_pop1ctz). The correlation between stocks of migrants by birth and by nationality is 0.927.

We completed missing Eurostat data from the OECD International Migration Database (Dataset MIG, Stocks of immigrants by country of birth in OECD countries).

For every country-pair, if some internal observations were missing, we linearly interpolated them using the STATA command ipolate

To "distribute" migrant stocks from each origin country by industry (two-digit level, NACE Rev. 2) in the destination country, we requested Eurostat migration data: by year, destination, region of origin (aggregated to EU3 and EU10), and industry at two-digit level. From these data we obtained the distribution of EU3 and EU10 migrants across industries in old EU member states for each year. The assumption here is that migrants from the same region of origin (EU3 or EU10) work in same industries.

Correlation of the proxy data with non-missing migration data collected from the national statistical offices is 0.72

A.3.2 TFP Calculation Description

Theoretically, TFP is calculated by dividing value added by the weighted average of labor and capital. When estimating it practically, however, one runs into endogeneity challenges due to the simultaneity of inputs and outputs. The literature on productivity estimations has comprehensively discussed this issue (Olley and Pakes

1996). If productivity shocks are observed by managers, they strategically choose their input, which creates a bias in the estimation due to simultaneity. Olley and Pakes (1996) were the first to introduce a semi-parametric estimation strategy that overcomes the endogeneity by using inputs of capital to proxy for the observed part of the productivity shock. Levinsohn and Petrin (2003) further develop the method and make it more feasible to estimate it empirically by using variable inputs such as materials as a proxy for the observed part of the productivity shock. As we observe materials in our dataset, we can apply the Levinson & Petrin methodology. We use the *prodest* command in STATA to easily implement it (Mollisi and Rovigatti 2017). This methodology has been extensively used in the literature (Blalock and Gertler 2004; Topalova and Khandelwal 2011) and further developed by Wooldridge (2009) and we check the robustness of our estimations using this methodology. The results are identical.

A.3.3 ORBIS Dataset Description

ORBIS is a commercial firm-level database conducted by Bureau van Dijck (BvDEP). It is a collection of business statements, ownership, ratings and news of mostly firms from the private sector. The firm's capital is measured in terms of book values, the number of employees provides information on labor inputs and consolidated or unconsolidated accounts shed light on the financial situation of the firm.

ORBIS contains data from more than 40 different sources, usually official institutions, with the aim of collecting company data to meet legal requirements. In addition, they are presented in a standard form to simplify the search and comparison of different companies.

Information about firms goes back 10 years. Information more than 10 years ago is not necessarily consistent, but can be purchased additionally.

ORBIS contains information for more than 375 million companies. Although the ORBIS database claims to cover all countries, coverage varies mainly from country to country, but also by sector, time and variables. As coverage can be very low for many countries, only a minority of countries can actually be used for comparative analysis.

The ORBIS dataset is not representative for the entire population of firms. Bajgar et al. (2020) find that the average ORBIS firm is larger, older and more productive. However, restricting the sample to only the best-covered countries, to firms with at least 10 employees and imputing missing value added improves the representativeness.

The data have been successfully used in academic economic research, mainly by papers studying multinational enterprises (Egger et al. 2009; Beer and Loeprick 2015). Moreover, Gal (2013) also uses ORBIS data to measure total factor productivity at the firm level. More information on the methodology and access formalities can be found online.[28]

A.3.4 Correspondence Tables

One challenge with the independent variables at the two-digit industry level (migration data, training, structural business statistics, etc.) arises from the change in NACE classification (Revision 2 changed Revision 1 in 2008). Some of our data are thus available only in Revision 1 and some only in Revision 2. At a two-digit level, we run into a problem of the many-to-many relation (several NACE Revision 1 codes can potentially map into several NACE Revision 2 codes).[29] We overcame this problem by creating a country-specific conversion matrix using Orbis data for 2009, where we can observe both Revision 1 and Revision 2 NACE codes for the same firm. For each NACE Revision 1 two-digit code, we obtain a corresponding weight (share) for each NACE Revision 2 code. The weights range between 0 and 1, sum to 1, and equal to the share of firms reporting a given Revision 2 code in the total number of firms with a given Revision 1 code.

A.4 Anecdotes from the Media

[28] https://www.bvdinfo.com/en-us/our-products/data/international/orbissecondaryMenuAnchor0/

[29] Correspondence tables are well-defined at a four-digit level, but we do not always have data available at that level.

SPIEGEL International

Reversing the Brain Drain

Poland Tries to Woo Its Young Back Home

Young Polish workers have flocked in the hundreds of thousands to the UK, Ireland and Sweden to find work since Poland's EU entry in 2004. Now Poland is faced with a serious lack of skilled workers and Warsaw wants to entice them back home.

The Guardian

Britain's gain is eastern Europe's brain drain

Fears over Latvia brain drain as economy struggles

The Economist

The brain drain in Eastern Europe needs a strong remedy

DW Made for minds.

OPINION

My Europe: Eastern brain drain threatens all of EU

European migration

The brain-drain cycle

Europe's commendable migration from east to west

Eastern Europe's workers are emigrating, but its pensioners are staying

The EU's newest members face economic decline unless they woo back workers, or recruit immigrants of their own

OPINION euobserver

Cohesion funds alone won't fix EU 'brain drain'

BBC

Hungarian government 'traps' graduates to stop brain drain

POLAND IN

Poland largest victim of brain drain in EU: report

Forbes

Losing Your Mind: Romania's Attempts To Counter The Brain Drain

FINANCIAL TIMES

Letter: Brain drain from eastern Europe has high price tag