Emigration and Firm Productivity: Evidence from the Sequential Opening of EU Labour Markets [a] (Preliminary draft)

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Abstract

This paper establishes a causal link between the emigration of skilled workers and firm performance. We exploit time, country, and industry differences in the opening of EU labour markets from 2004 to 2014 as a source of exogenous variation in the emigration rates from new EU member states. Using firm-level panel data from ten East European countries, we show that the outflow of skilled workers reduces firm total factor productivity. One explanation for this effect is the increased job turnover, which lowers firm-specific human capital. We find that the most productive firms adapt more easily to emigration as they are better able to retain and train their workers.

JEL classification: O15, D24, F22, J24

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1 Introduction

Little is known about how the emigration of skilled workers affects firm productivity. While policy-makers and managers are concerned because skilled workers are leaving their jobs to follow better opportunities abroad, there is predominantly anecdotal evidence of a negative effect on firms. The reason for the lack of systematic evidence are scarcity of firm-level data from emigrants' countries of origin and the endogeneity of migration flows. It could well be that the causation goes the other way and that migrants are leaving the least productive firms or that an omitted variable is biasing the estimations. As migration reaches new peaks, the need for the causal evidence is increasing. Central and Eastern Europe is one region that has experienced particular high emigration rates in the recent years. Following the EU accession of Central and Eastern European countries,[1] migration flows from these states to old EU member states[2] have increased considerably: In 2003 the number of EU10 migrants residing in EU15 constituted 846,000 people; by 2014 this number had reached 3,95 million. As of 2014, 25% of the post-accession EU10 migrants had tertiary education. To compare, among EU10 non-migrants, people with university degree accounted for 13.5%.[3] Although there are important positive consequences of free labour mobility in terms of lower unemployment and a better skill match, there have been growing concerns that the emigration of skilled workers has created a severe challenge for source countries (Kahanec 2012; OECD 2013; Zaiceva 2014).

This paper establishes a causal link between skilled emigration and firm performance in source countries. As "skilled", we denote individuals with either tertiary education or a professional qualification. To identify the effect of interest, we exploit changes in EU labour mobility legislation from 2004 to 2014. The transitional provisions applied by old EU member states created a quasi-experimental setting by allowing earlier or later free labour mobility for certain categories of EU10 workers.[4] While these transitional provisions were in force, emigration opportunities for EU10 citizens varied, depending on

[1]The 2004 entry countries (EU8): Czech Republic, Estonia, Hungary, Latvia, Lithuania, Poland, Slovakia, Slovenia; the 2007 entry countries (EU2): Bulgaria, Romania. We also refer to the group as EU10.

[2]Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, Netherlands, Portugal, Spain, Sweden, United Kingdom (EU15

[3] Source: Eurostat LFS Data. Only migrants, who entered the EU15 after the EU accession, are taken into account.

[4]In the paper, we consider legislation changes in EU15. Other EEA members: Iceland, Liechtenstein, Norway, and Switzerland also applied transitional provisions; however, due to missing data, we exclude them from our analysis.

their country of origin and the industry they were qualified to work in. Using firm-level data from EU10 countries, we show that firms in industries, which were exposed to higher outflows of skilled workers, experience a drop in total factor productivity (TFP). The estimates are qualitatively robust to various measures of TFP and firm profits. We also find evidence for a shorter tenure of workers in sectors that are strongest hit by emigration. We further document an increase in firms' personnel costs and training expenditures following the outflow of workers.

We develop a theoretical framework to illustrate that one plausible channel behind this result is a reduction in firm-specific human capital. Better emigration opportunities induce skilled workers to quit. This results in higher job turnover rates that lower the stock of firm-specific skills and knowledge. The effect is captured by TFP, as this form of human capital is not fully accounted for in wages. The firm has several ways to adapt to higher quitting rates of skilled workers. It can substitute labour with capital (see Dustmann and Glitz (2015) for the case of immigration), substitute high-skilled workers with low-skilled workers or increase training for new hires. While we find heterogeneity among firms, our empirical analysis shows that firms tend to increase training, which in turn raises their personnel costs. This mechanism fits well into the previous literature. Konings and Vanormelingen (2015) find that the productivity of workers increases by more than their wage after they have participated in training. Consequently, if trained workers are leaving, this is not only captured by labour productivity but by the residual TFP. Jäger (2015) shows that longer-tenured workers are harder to replace with outsiders. The relationship between job turnover, firm-specific human capital, and firm productivity has been further analyzed by Brown and Medoff (1978), Shaw (2011), Strober (1990), and Yanadori and Kato (2007).

Panel data allow us to account for firm heterogeneity and explore the link between firms' characteristics and their sensitivity and adaptation to higher quitting rates of workers. We find that innovating and foreign-owned firms substantially increase their personnel costs. More productive firms are able to (at least, partly) match wages offered abroad, provide more training, and, therefore, prevent the loss of firm-specific human capital. Moreover, more productive firms face less severe financial constraints and have access to larger internal labour markets. This enables them to faster substitute for quitting workers.

Apart from analysing the reduced-form effects of legislation changes on firm productivity, we also perform 2SLS regressions to estimate the effect for firms, which effectively experienced skill shortages due to higher emigration rates. Changes in EU labour mobility laws strongly predict skill shortages as reported by firms in EU10. This allows us to use

the legislation changes as an instrument. We argue for the validity of such instrument: Detailed sector- and country- specific legislation changes had not been anticipated and are uncorrelated with other integration-related events, such as the free movement of goods or capital. Using annual data from the European Commission Business Survey and the BEEPS Survey by the EBRD, we find that a one percentage point increase in instrumented skill shortages leads to a 1.6% drop in firm TFP and 3% increase in personnel costs.[5]

To the best of our knowledge, this paper is the first to exploit industry-level variation in labour mobility laws to causally evaluate the effect of emigration on firm performance. By providing micro-level evidence, we contribute to the literature on the economic effects of emigration (brain drain) including Clemens (2013), Docquier and Rapoport (2012), Freeman (2006), and Grossmann and Stadelmann (2011, 2013). In particular, we complement the research, which investigates the consequences of the recent emigration wave from the EU10. Mayr and Peri (2009) develop a model to study the consequences of European free labour mobility on human capital in the sending 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) estimated the effects of emigration on wages in Poland and Lithuania and found that wages increased for the stayers.

Another contribution of this paper is the creation of an extensive dataset that merges migration and firm-level data and enables us to conduct micro-level analyses. We use harmonized balance-sheet and profit-loss panel data, provided by Bureau van Dijk. The data covers up to 80% of all firms in new EU member states in the period 2000-2014. We combine this information with the firm-level BEEPS survey, conducted by the European Bank of Reconstruction and Development (EBRD) throughout 2002-2013, the European Commission Business Survey, and the Eurostat Labour Force Survey data. The microeconomic analysis relates this paper to the emerging migration literature that focuses on the firm as the unit of analysis. Similarly to the trade literature that benefited greatly from the introduction of the firm-level perspective (Melitz 2003), we expect that the migration literature can gain richer insights into the consequences of migration by investigating firm-level outcomes. Kerr et al. (2014), Kerr et al. (2013), Kerr (2013), for instance, are encouraging this approach for the analysis of immigration. Accounting for

[5]Haskel and Martin (1993) were, to our knowledge, the first to analyse the effect of skill shortages on firm productivity. Using UK survey data of 81 industries from 1980-1986, they found that a 1% increase in labour shortages was associated with a 1.8%-2.1% decrease in aggregate industry productivity. Adding to this, Wallis (2002) found that for every percentage point increase in skill shortages, wages increased by 0.09 percentage points.

firm heterogeneity as well as firm entry and exit is important if one intends to shed light on microeconomic mechanisms, which shape the observable effect of migration on macro outcomes.

Peri (2012), Kerr and Kerr (2013) and Kerr et al. (2014), Paserman (2013), and Mitaritonna et al. (2014) study the effects of immigration on firm productivity in the US, Israel, and France. They find that an increase in the supply of foreign-born workers positively affects firm productivity due to a faster growth of capital and the specialisation of natives in more complex tasks. Lewis (2013) furthermore finds that besides increased investment, firms also adapt new technology. Using firm-level German data, Dustmann and Glitz (2015) analyse how industries and firms respond to changes in the local labour supply. They find that immigration alters the local skill composition and investigate three adaptation mechanisms: a change in factor prices, a within-firm change in skill intensity, and an adjustment through the entry and exit of firms. Our research is complementary to this literature. While the authors look at the effects of immigration on firms, we focus on the consequences of emigration.

The paper is organized as follows. The next section provides background information on the EU opening and transitional provisions regarding free labour mobility, which helps to understand our identification strategy. Section 3 outlines a theoretical framework to illustrate a channel that links skilled emigration and firm productivity. Section 4 describes the data, followed by section 5 that presents the empirical specification. Section 6 discusses the results including heterogeneous effects, while section 7 provides robustness checks. Section 8 concludes.

2 Transitional Arrangements for the Free Movement of EU10 Workers following the EU Enlargements in 2004 and 2007

This section provides background information on the transitional provisions applied by old EU member states in 2004-2014. It shows how the gradual opening of the EU labour markets had created time, country, and industry-level variation in the emigration rates of EU10 citizens.

In 2004, ten Eastern and Southern European Countries joined the EU: Cyprus, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Malta, Poland, Slovakia and Slovenia. While free mobility of goods and capital was introduced either prior to or at the point

of accession by all countries, free labour mobility was initially restricted. Some EU15 countries feared an inflow of cheaper labour. The EU Commission thus allowed the old member states to unilaterally restrict their labour markets by national laws for a period of seven years. These transitional arrangements were used against all new members in the same way but excluded Malta and Cyprus. In 2007, Bulgaria and Romania joined the European Union, also facing the transitional agreement rules.

The option to unilaterally restrict labour markets generated different rules within the EU. While Ireland, Sweden, and the UK decided to open their labour markets immediately in 2004 without sector restrictions, other countries delayed the access or applied special job schemes in certain industries. Denmark, Greece, Spain and Portugal, for instance, removed restrictions only in 2009. France, Belgium, Netherlands and Austria opened their labour markets gradually, allowing only workers in certain industries and introducing quotas. Germany kept the labour market almost completely closed until the expiration of the transitional agreements (2011 for EU8; 2014 for EU2). Table 10 in the appendix provides an overview of the precise opening dates and industry details per country. Figure 4 illustrates the variation this creates in our data.

This sequential opening by country, year and industry had a significant effect on migration rates. Constant (2011) and Kahanec (2012) provide descriptive evidence of EU migration flows following the Enlargement. They show that the transitional agreements influenced the movement of migrants. The UK and Ireland, for example, have become the main EU destination country for Polish, Slovakian and Latvian workers. Kahanec et al. (2014) applying a difference-in-differences analysis confirm that outward migration from EU10 increased with the EU entry, but its full potential was hampered by the presence of transitional arrangements.

One might argue that the restriction of a country's labour market is endogenous and is related to local labour market conditions. Germany, for instance, experienced high unemployment rates during the mid-2000s and this was one of the reasons for its labour market restrictions. However, while the transitional arrangements are endogenous to labour market conditions and firm productivity in the receiving country, they are exogenous to firm outcomes in the sending states.

Another argument against our identification is that the decisions to open a particular industry by EU15 countries were to some extent endogenous to conditions in the new member countries. For example, mobility restrictions might have been directed at the EU10 citizens working in countries and industries with high volumes of EU15 FDIs. This is not the case for the following reasons. First, EU15 could not differentiate transitional

provisions across countries in EU8 and EU2 groups. Second, this proposition is hard to reconcile with significant time-variation in the removal of provisions. One might further suggest that the industry-specific timing of labour market openings coincided with trade liberalization. Yet, all new EU member countries had signed and enforced Free Trade Agreements with the EU prior to their accession. It is plausible to conclude that the application of transitional provisions by EU15 was driven mainly by their own economic conditions and is thus exogenous to firm outcomes in EU10.

The transitional agreements have not only affected the employed people in the new member states but have also given new opportunities to the unemployed. One might assume that the unemployed had the highest incentives to leave their countries and look for work abroad. This would weaken our identification as the emigration of unemployed workers would not lead to the loss of firm-specific human capital and would leave firm productivity unaffected. Another concern is that people might change industries as they migrate. This will again go against our approach. It is plausible to assume though that people have the smallest emigration costs if their industry opens. If they end up in another industry after migration, this does not affect our results as we are only interested in the fact that they left and it does not matter in which industry they actually work in their destination country.

3 Conceptual Framework

3.1 General Setting

Our conceptual framework illustrates the consequences of skilled emigration at the firm level. Using a partial-equilibrium framework, we generate predictions about the changes in firm TFP, factor demand, and training provision.

We assume that there are search frictions in the labour market: jobs are destroyed at an exogenous rate and firms are not immediately matched to new workers. The turnover rate is defined as separations over total number of employees. In order to fill vacant positions, firms post costly vacancies. In this setting, skill shortages are not a disequilibrium phenomenon, but correspond to some measure of search frictions (i.e. the number of posted vacancies for skilled employees; the average duration of a skilled vacancy). Better work opportunities abroad induce higher emigration. Consequently, the job destruction rate and the search period increase, exposing firms to skill shortages.

We allow firm-specific human capital to explicitly enter the production function.

Higher labour turnover destroys part of the firm-specific human capital. Since the latter is not fully captured by wages, this loss translates to a drop in the TFP. In this way, we characterize one possible micro channel, through which the skilled emigration directly affects firm productivity[6].

The economy consists of a representative firm that produces output according to the production function:

$$Y = Af(K, L_s, L_u) \tag{1}$$

$Af()$ is a general production function with K - the capital input, L_s and L_u - the skilled and unskilled labour inputs. $f()$ increases in the production factors K, L_s, L_u; exhibits diminishing marginal returns to K, L_s, L_u and is twice-differentiable. A represents TFP. We assume that A entirely consists of firm-specific human capital, i.e. knowledge and abilities of skilled workers that are not transferable to other firms. This firm-specific human capital can accumulate either through skilled workers' learning-by-doing (λ) or through firm's investment in firm-specific human capital, i.e. training (τ). We assume that learning-by-doing and training are imperfect substitutes and that the elasticities $\gamma_\lambda + \gamma_\tau < 1$.

$$A = \lambda^{\gamma_\lambda} \tau^{\gamma_\tau} \tag{2}$$

The learning-by-doing component represents aggregate firm-specific knowledge of skilled workers. Intuitively, it is proportional to workers' tenure in a firm. It represents part of the return to tenure that accrues to a firm (i.e. it is not reflected in workers' wages).[7] In addition, firms increase firm-specific human capital by providing initial training t to all new hires. Training is continuous and has per-hour costs $c_t > 0$.

Each period L_s and L_u workers are involved in the production process. In the end of each period, a proportion δ_s (δ_u) of skilled (unskilled) jobs are destroyed. To fill destroyed jobs with new workers, a firm posts vacancies, which are matched with probability q_s (q_u). In equilibrium, the number of destroyed jobs must equal the number of matched vacancies:

$$V_i = \frac{\delta_i L_i}{q_i}, i = s, u. \tag{3}$$

[6]On a macro level, this problem was examined by Grossmann and Stadelmann (2011). In their overlapping generations model, the drop in TFP is attributed to less firm entry and, consequently, to the reduction in human capital externalities of skilled employees.

[7]See for example Shaw (2011) for an extensive literature review that concludes that higher turnover reduces productivity due to losses in firm-specific human capital.

We assume that posting vacancies creates a search cost of c_s (c_u) per period.

We can directly link firm-specific human capital to the job destruction rate. Average tenure is equal to $1/\delta_i$, $i = s, u$. The aggregate learning-by-doing (of non-replaced workers) can be represented as $\lambda = L_s\frac{1}{\delta_s}$. Firms also provide each new worker with some amount of training. Assuming that this knowledge does not depreciate over time, the aggregate firm-specific human capital due to the initial training of skilled employees can be expressed as $\tau = tL_s$. Substituting in (2), yields $A = (\frac{1}{\delta_s})^{\gamma_\lambda} t^{\gamma_\tau} L_s^{\gamma_\lambda+\gamma_\tau}$.

3.2 Firms' Optimisation

The firm chooses inputs K, L_s, L_u and the amount of initial training t for the skilled employees to maximize profits Π:

$$\Pi = PY - \sum_{i=s,u} (w_i L_i + c_i V_i) - c_t t q_s V_s - rK \tag{4}$$

s.t.

$$\frac{V_i}{L_i} = \frac{\delta_i}{q_i}, i = s, u.$$

Using the constraint to substitute for V_i yields the total personnel costs of skilled workers: $L_s(w_s + c_s\frac{\delta_s}{q_s} + c_t t\delta_s)$. The costs comprise wages, search costs, and the training expenses of newly hired workers. Similarly, total personnel costs of unskilled workers are equal to $L_u(w_u + c_u\frac{\delta_u}{q_u})$. We assume that there is no training for unskilled workers.

Emigration of skilled workers raises $\frac{\delta_s}{q_s}$, as both turnover ($\frac{\delta_s}{L_s}$) and vacancy duration ($\frac{1}{q_s}$) increase.[8] Higher emigration rates thus exert a direct negative effect on firm's profits: due to higher turnover and lower average tenure of employees, part of the firm-specific human capital (TFP) is destroyed and vacancy costs increase.[9] We provide a solution to the model with a simple Cobb-Douglas production function in the Appendix.

By inducing higher search and training costs for skilled workers, emigration augments personnel costs and thus affects relative input demand of the firm. Further, the incentives for training change. Providing newcomers with more training (intensive margin) may substitute for losses in the firm-specific human capital due to shorter tenure. Yet, lower

[8] Without loss of generality, we assume in the following that δ_s increases. Assuming an increase in q_s would lead to the same results.

[9] The model is generalisable to the situation in which both skilled and unskilled workers emigrate. In this case turnover would increase for both groups but firm-specific human capital would only be lost for skilled workers.

training provision might be optional, given a lower expected tenure. The precise direction of the sign thus depends on firm characteristics and will be dealt with in the section on heterogeneity.

3.3 Comparative Statics and Simulations

A higher emigration rate leads to more job destruction: δ increases.[10]

1. An increase in δ leads to a higher turnover, which decreases firm-specific human capital and thus total factor productivity.
2. An increase in δ leads to a higher turnover, which has an ambiguous impact on training. On the one hand, firms can use training to substitute for the loss in the "learned-by-doing" human capital. On the other hand, shorter tenure increases marginal training costs (when keeping number of skilled workers fixed).
3. An increase in δ increases the price of high-skilled workers. Depending on the elasticity of substitution between the inputs, firms might find it optimal to substitute high-skilled workers with low-skilled or high-skilled workers with capital.

3.4 Heterogeneity

Different firms are affected differently. For some it might be profitable to train, for others to substitute with capital and for others to substitute with low-skilled workers. Some firms will find it easier to adjust and can alleviate the negative effects of TFP, while other firms struggle with the adjustment and experience loss in TFP. This depends on a firm's initial productivity, the elasticity of substitution between inputs, the price of training, the pool of applicants. Our data analysis will shed more light on heterogeneous effects across firms of different size, ownership, innovation activity and technology.

4 Data

For our analysis we use firm-level financial and survey data, aggregate industry and country indicators, detailed migration data, and information from EU labour legislation.

We obtain firm-level data from Bureau Van Dijk's AMADEUS database that provides standardized annual balance-sheet and profit information for European public and private

[10] This assumes that the migrants have been employed before.

companies. We work with an unbalanced panel of about 110 000 firms located in new member states. The period covered ranges from 2000 to 2013, and, on average, there are 5 annual observations for each firm. The sample includes companies in manufacturing, construction, retail trade and services. Apart from financial reports, the dataset provides information on firms' patenting activities, ownership structures, export markets, and exit status (such as bankruptcy or liquidation).

We complement this data with firm-level information from the Business Environment and Enterprise Performance Surveys (BEEPS) administered by the European Bank for Reconstruction and Development (EBRD) in all new member states. The survey was conducted in 2002, 2005, 2009 and 2012 and contains an extensive questionnaire on firms' financial performance (self-reported), workforce composition, management practices, innovation, and perceptions of the business environment (including availability and quality of human capital, financial constraints, and corruption). The survey data provides a representative sample of manufacturing, construction, service, and retail trade firms. In total, there are 13 972 firm-year observations, of which 2556 (1293 firms) make up an unbalanced panel.

Migration data is taken from Eurostat Labour Force Surveys, which take place annually in all EU member countries and cover around 5% of the national population. The survey provides demographic information on individuals, including their country of birth, education level, occupation, and employing industry.

To construct the Free Movement variable, we use the Labour Reforms database (section on labour mobility) of the EU Commission and complement it with information from the national legislation of old EU member states.

A measure of skill shortages is taken from the EU Commission Business Survey, which is conducted quarterly in all EU member countries by the Directorate General for Economic and Financial Affairs (DG ECFIN). The survey addresses representatives of the manufacturing, service, retail trade, and construction sectors and asks for firms' assessment and expectations of the business development. Among other questions, the survey's participants are asked to evaluate factors limiting their production (such as labour, access to finance, demand, and equipment). The EU commission publishes information on a two-digit industry level, thus the obtained measure is equal to the share of firms in a given industry reporting to be constrained by labour. To match the data to other datasets, we aggregated quarterly indicators to annual levels. As an alternative measure, we consider firms' replies from the BEEPS survey, which asks respondents to evaluate the importance of "inadequately educated labour" as an obstacle for business. Following the

EU Commission Survey, we also aggregate individual firms' replies on a two-digit industry level.

As additional covariates, we use aggregated (two- and four-digit) industry level data, which is available for all EU member states and is harmonized by Eurostat. The structural business statistics database contains annual information on industries' performance, including output, investment, employment, and personnel costs. Macroeconomic controls (GDP, FDI, unemployment, interest rates) are taken from the Worldbank statistical database.

5 Econometric Specification

The aim of the empirical analysis is to determine how firm productivity in EU10 countries has changed in response to the emigration of skilled workers. For identification, we exploit legislation changes as exogenous shocks to emigration rates. In this section, we first discuss the Free Movement variable, which summarizes the EU15 labour mobility laws and enters the regressions as the main exogenous variable or the instrument for skill shortages. We then present the reduced-form and 2sls specifications.

5.1 Construction of the Free Movement Variable

The Free Movement (FM) variable measures the exposure of a specific EU10 industry to skilled emigration. We construct it directly by aggregating information about EU15 labour mobility laws. We use it as the main explanatory variable in our baseline empirical specifications rather than an instrument for migration flows, partly because there is no disaggregated data on actual emigration rates.[11] As an alternative to the emigration data, we use industry-level information on skill shortages and instrument it with the Free Movement variable in the 2sls regressions.

A country-industry-year cell makes up one observation. Industries are represented at the NACE two-digit level. The main period under consideration is from 2004 to 2014 (from the accession of EU8 countries to the termination of all transitional provisions applied to EU2). First, for each observation we construct a set of 15 dummies - D_{cc_jit},

[11]The Eurostat Labour Force Survey provides information on the industry, education, and occupation of immigrants, but aggregates the country-of-origin information. While observing immigrants in EU15, we can only say if they come from EU8 (2004 entry) or EU2 (2007 entry). Even if the detailed origin information were available, though, it would likely be noisy and the labour force sample would have small numbers in the specific country-industry-year cell.

with each dummy corresponding to one of the 15 old EU member countries, c_j. A dummy takes the value of 1 if according to the legislation of an old EU member, its corresponding industry i is open to labour migrants from a given new member state c. For example, the UK completely opened up its labour market for the EU8 group in 2004. Therefore UK dummies for all industries for all EU8 countries equal 1 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 labour market access only in construction, tourism, and catering. France dummies for EU8 industries take a value of 0 until 2008, except for the three mentioned sectors.

One of the limitations of the legislation dummies is low industry-level variation. Austria, Germany, France, Italy, and the Netherlands, for instance, did not explicitly specify which industries are open to labour 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 old EU labour markets to absorb migrants. To account for this, we multiply the legislation dummies D_{cc_jit} by a measure of skill shortages in a given industry of a j_{th} old EU member state. For this, we use the share of firms (in destination industries) reporting to be constrained by the labour factor. These data are available from the EU Commission Business Survey. Such modification controls for implicit legislation changes and for differences in labour market conditions across and within industries in old EU members.[12] Easiness to find a job, which increases in sectors experiencing skill shortages, can be another important criteria for worker mobility. A possible concern with such a modification is that skill shortages in the old EU member states might not be fully exogenous to firm productivity in EU10 countries, due, for example, to common technology shocks. We can control for this by including industry-specific time dummies or an average measure of skill shortages in a given industry for all EU members. Another concern is that labour demand could increase in EU15 industries, which after the EU enlargement had become more competitive relative to their rivals from new member states. In this case, however, one would expect to see negative tendencies in EU10 firm performance already prior to the outflow of workers. We can also control for higher product-market competition by including a mark-up measure.

To summarize the set of 15 dummies in a single measure, we apply special weights

[12]This allows to capture, for example, a decrease in demand for foreign labour force during and after the economic crisis in 2008-2009. At this time, many labour markets were already open for EU10 citizens, but effective job possibilities were slim. De-jure, only Spain reacted to the worsening of economic conditions by reintroducing restrictions for Romanian citizens in 2011.

that reflect how strongly the opening of a particular EU15 labour market affects the citizens of a given new member state. It is reasonable to assume that labour migrants, for example, from Estonia were more sensitive to the opening of the Finnish labour market than the Portuguese one. One approach is to use bilateral distances between the two largest cities of each source and destination countries as a measure of proximity: the shorter the distance, the larger is the weight for a corresponding EU15 labour market. Alternatively, we obtain the weights by using EU10 migration stocks as of year 2000 in each of the EU15 countries:

$$w_{c,c_d} = \frac{Stock2000_{c,c_d}}{\sum_{j=1}^{15} Stock2000_{c,c_j}} \tag{5}$$

Namely, a weight for each pair of a new member state (c, source country) and an old member (c_d, destination country) is equal to the share of migrants from this source country living in the destination country relative to the total number of migrants from this source country in EU15. Such weights reflect historical and geographic ties between EU members and account for network effects, which facilitate migration decisions. The results are robust to applying simple averaging of the legislation dummies across the 15 destinations.

The legislation information is summarized in one variable:

$$FM_{cit} = \sum_{j=1}^{15} w_{c,c_j} * D_{cc_jit} \tag{6}$$

FM_{cit} is the value for one observation (source country-industry-year). D_{cc_jit} - legislation dummy for openness of the labour market in a j_{th} old EU member's corresponding industry for the citizens of a given source country in a given year. w_{c,c_j} - weights. To ensure the comparability of different versions of Free Movement variables, we standardize them to be in the range [0;1].

To confirm the exogeneity of the Free Movement variable, we check if firms' outcomes prior to 2004 predict changes in the legislation over 2004-2014. We also run several placebo tests. We report the results in the section on robustness.

5.2 Baseline Models

The reduced-form empirical specification is represented below:

$$Y_{fict} = \beta_1 FM_{ict-l} + \beta_2 X_{fict} + \beta_3 I_{ict} + \beta_4 C_{ct} + \tau_t + \nu_{fic} + \epsilon_{fict} \tag{7}$$

where Y_{fict} are different performance measures of a firm (f) in industry (i), country (c) and year (t). FM_{ict-l} indicates the Free Movement variable. We include it in equation 7 with a lag l. β_1 is the reduced-form effect of the legislation change on a firm-level outcome. X_{fict} is a set of time-varying firm controls, such as age and capacity utilization. I_{ict} includes country-specific industry controls such as total investment, average mark-up (ratio of revenues to costs), and inward FDI. These variables account for variation due to other shifters of labour demand within an industry of a particular country, namely, technical change or higher competition. Industry-specific total sales and skill shortages control for shocks, which are common across all EU countries. C_{ct} is a vector of macroeconomic covariates, accounting for country-wide changes: the GDP growth rate and FDI inflows. All monetary variables are in natural logarithms. τ_t are time dummies. ν_{fic} represent firm fixed effects, and ϵ_{fict} is the error term. 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 focus of this project is to estimate the effect of emigration of firm total factor productivity. We compute firm productivity in several ways: using a TFP-index and a semi-parametric approach as in Levinsohn and Petrin (2003). The latter method allows to overcome the simultaneity bias between firms' inputs and unobserved productivity shocks. For details regarding the TFP calculation, we refer to the Appendix (9.3)). As alternative measures of productivity, we consider firm profits: $\frac{EBIT}{Assets}$ calculated as the ratio of earnings before interest and tax over assets.

To understand how firms adjust, we look at several other variables: personnel costs per employee (which include wages, hiring and training costs) and the capital/labour ratio. In addition to the Amadeus dataset, we also analyse data from the BEEPS survey, which contains information on firm training.

We then investigate the heterogeneity in firm outcomes. According to the conceptual framework, the effect of skilled emigration on firm TFP is higher in industries, where firm-specific human capital is more important. To provide the empirical evidence, we estimate the regression for a subsample of industries, which pay high premia to tenure. To further analyse firms' adjustment to emigration, we make use of cross-industry variation in the substitutability between high- and low-skilled labour and between skilled labour and capital. We also look at the within-industry firm heterogeneity by estimating the regressions for subsamples of foreign-owned and innovating firms. These firms are arguably

the most productive and could faster adapt to the outflow of skilled workers. They are more likely to have efficient training curricula, larger internal labour markets, and face fewer financial constraints.

Due to the lack of disaggregated migration data, we cannot directly test the relevance of the Free Movement variable for the actual emigration rates from the EU10. Instead we can check if the EU15 labour mobility laws explain the increase in skill shortages as reported by the EU10 firms. The baseline first-stage regression takes the following form:

$$SH_{ict} = \gamma_1 FM_{ict-l} + \gamma_2 I_{ict} + \gamma_3 C_{ct} + \tau_t + \kappa_{ic} + u_{ict} \tag{8}$$

SH_{ict} is the industry-country-year measure of skill shortages. γ_1 - the coefficient of interest - reflects the marginal contribution of the Free Movement variable, given industry- and country-specific time-varying covariates (I_{ict}, C_{ct}), and time dummies (τ_t). By including industry-country fixed effects κ_{ic}, we identify the Free Movement effect only from within-industry variation in the propensity to emigrate.

We run a second-stage regression, similar to 7, but instead of the Free Movement variable, use the instrumented measure of skill shortages. The coefficient $\hat{\beta}_1$ thus captures the productivity effect of skill shortages caused by the transitional provisions. It is identified only for industries, where the legislation changes created binding skill constraints for firms.

As a robustness check, we estimate a model similar to 8 but for other dependent variables: financial, equipment, and demand constraints, which are also reported by EU10 firms and measured in the same way as skill shortages. If our first-stage results are caused by higher emigration rates following the legislation changes rather than by other industry-country specific shocks, the coefficient γ_1 in the placebo regressions should be insignificant.

6 Empirical Results

This section presents and discusses empirical results. For all reported models, the Free Movement variable was constructed using distance-based weights.[13] As discussed in section 5.1, we interact the legislation dummies with a measure of skill shortages in a given industry of a particular old EU member. All regressions include firm fixed effects and thus capture within-firm variation in performance as a response to changes in an industry's human capital supply. The sample spans over 2000-2013 and includes firms with at least two years of available financial data to calculate the TFP index. As a note of caution, we

[13]The results qualitatively hold with migration-based weights and are available upon request.

might not capture companies at the lower tail of the productivity distribution, if they are less likely to be included in the sample. Based on observables, though, firms in the regression samples are not statistically different from the ones in the full sample (see table 1). We used the largest possible number of firms with non-missing observations. The number of firms across regression results slightly varies due to differences in the availability of variables.

6.1 Reduced Form Regressions

Table 2 presents the reduced form estimations: we regress firm outcomes directly on the Free Movement variable. We use a one-period lag for the Free Movement to account for some inertia between the legislation change and the migration decisions. All dependent variables are in natural logarithms, and the Free Movement variable in the range from 0 to 1. The coefficients may be interpreted as the log point change in dependent variables, when the FM increases from 0 (no free labour mobility within EU for workers qualified to work in a particular industry) to 1 (maximum exposure to free labour mobility in our sample).

For the main sample of firms, the effect of Free Movement on productivity is negative. The result is robust to different measures of productivity, to the exclusion of outliers (firms with sales below 1_{st} and above 99_{th} percentiles), and to the exclusion of firms that entered the market after 2002. Throughout 2004-2014, EU10 industries faced varying increases in the exposure to emigration. Figure 4 provides an illustration of this variation. The maximum annual increase in the Free Movement variable in our sample equals 0.52 (for certain industries in Romania in 2007), while on average EU10 industries experienced a maximum annual jump of 0.25. We can use this information to give a quantitative interpretation of our result. One year following the maximum increase in labour mobility, firm TFP drops by 0.25*0.234 = 0.059 log points. Given an average TFP of 29500 EUR (estimated by the Levinsohn-Petrin method), this translates to annual losses of 1725 EUR per firm.

We can also see that firms adjust to emigration by increasing personnel costs. The annual increase in the Free Movement value of 0.25 would lead to 0.25*0.27 = 0.0675 log point increase in personnel costs per employee. Under average annual employee costs of 7840 EUR, this leads to additional 530 EUR per worker. The change in the capital/labour ratio is positive, but imprecisely estimated.

We further explore the effects of emigration using firm-level data from the BEEPS survey. Table 3 presents the reduced form estimations. BEEPS contains only a limited

number of firms with available panel data, therefore, in the reported specification we pulled firm observations together, adding firm-level covariates: lagged sales, capital, quadratic terms for firm age and lagged number of employees, share of foreign capital, share of export in sales. All regressions are estimated with country*year (c*y), country*industry(c*i), and industry*year(i*y) fixed effects. The remaining variation in dependent variables should come from country-industry-year changes in the value of the Free Movement variable. As with the Amadeus data, we find a negative effect of the EU labour market opening on firm total factor productivity. As an additional insight, we report significant increases in employee training by firms in industries, which have potentially experienced higher labour emigration. The effect on wage is positive, but imprecisely estimated, which could be related to the data quality or to the fact that it does not include other components of personnel costs.

Given the negative effect of the Free Movement variable on firm TFP, the question arises on the channels behind such result. One plausible explanation is the reduction in firm-specific human capital. The opening of EU labour markets decreased emigration costs for the citizens of new member states. Higher emigration rates translated to higher number of job separations, which should have lowered average tenure of workers in EU10 firms. Following the conceptual framework, an increase in turnover leads to lower firm productivity. New hires are not perfect substitutes for emigrants, since they are missing the firm-specific skills and knowledge. We cannot directly observe firm-level information on tenure, but instead can use Eurostat LFS data to check if the Free Movement variable affected average tenure in EU10 industries. The results are presented in table 4. In line with our hypothesis, industries exposed to higher labour mobility experience a decrease in average tenure. The estimates are robust to different versions of the Free Movement variable and to the inclusion of country-specific time trends. To check for the presence of pre-trends, in one of the specifications, we add a one-period forward of the Free Movement variable, which turns out to be insignificant.

6.2 Heterogeneity

In the main specification, we analysed the effect of free movement for the full sample of firms. To check for heterogeneous effects, we estimate the specification 7 for different sub-samples of firms. We first look at within-industry heterogeneity. We differentiate firms by size and by productivity. As most productive we consider firms with registered patents and firms with foreign capital. We then look at sector heterogeneity, in particular in terms of human capital and technology intensity.

Tables 5 and 6 show the results for foreign-owned and innovating firms. The estimated effect of free movement on firm TFP has a smaller magnitude compared to the full sample and loses its statistical significance. At the same time, the estimated coefficients for personnel costs and capital/labour ratios suggest that these firms adjust much stronger to the increased emigration opportunities of their workforce. Foreign-owned firms increase their personnel costs significantly more. This might be due to better financial leeway. In this way, they can offer wage increases to retain workers and training to newcomers to teach firm-specific human capital. Patenting firms seem to adapt in particular through increasing the capital/labour ratio. These firms might also be able to provide an interesting work environment and have retention initiatives to keep their essential research staff. There is also evidence that innovating firms benefit from reverse knowledge flows and increased research networks through their former employees (Kaiser et al. (2015), Braunerhjelm et al. (2015)).

Besides looking at firm heterogeneity, it is also informative to distinguish between sectors with different characteristics. We are interested whether human-capital or high-tech[14] intensive sectors are hit harder by emigration. For this, we calculate the average percentage of tertiary educated workers in every sector and split all sectors at the median into human capital intensive and not human capital intensive sectors. Human capital intensive and high-tech sectors do not experience such sharp drops in TFP. The reason for this is that firms in these sectors increase personnel costs by much more and are thus either able to retain their workers or can offer adequate training to newcomers.

6.3 Skill Shortages as the Consequence of the Emigration, 2SLS Regressions

The reduced form regressions represent the "intention-to-treat" effect. It is furthermore of interest to estimate changes in outcomes for firms, which have effectively suffered from the outflow of skilled workers. We consider skill shortages as an indicator for this problem. If changes in EU15 labour mobility legislation have indeed induced higher emigration rates of the qualified workforce, we would observe increasing skill shortages as reported by firms in new member states. The measure of skill shortages is described in the section 4 above.

Table 7 presents the first-stage estimation results for four modifications of the Free Movement variable. In specifications 1 and 2, we use distance-weighted FM dummies, in 3 and 4 - FM dummies weighted with migration stocks. In specifications 2 and 4, FM

[14] According to the EU Commission definition of high-tech industries, classified by NACE 2 digit.

dummies are in addition interacted with skill shortages in destination industries of *old* EU member states. We include a number of covariates to switch-off demand-driven changes in the reported skill shortages. Countries GDP growth rate and FDI inflows (GDP_{ct}, FDI_{ct}) control for general country-specific shocks. Lagged investment ($investment_{ict}$) accounts for country-industry-specific increases in skill shortages due to the expansion of existing companies or new entries. Average skill shortages in a given industry in EU15 countries ($Mean\ skill\ sh_{it}$) control for industry-specific labour-demand shocks, which are common across all EU members. The FM coefficient thus captures residual variation in the reported skill shortages, which arises due to the emigration of people qualified to work in particular industries. All four FM modifications return similar results: complete opening (from FM=0 to FM=1) of all EU15 (industry-specific) labour markets would have resulted in a 5-12% increase in skill shortages for firms (within the corresponding industry) from a new member state. FM coefficients are statistically significant, and the F-test rejects the null hypothesis of insignificance for all four modifications.

Table 8 presents 2SLS estimates with the skill shortages as an instrumented independent variable. We estimate the reported models using the distance-weighted instrument, interacted with skill shortages across industries of destination countries, the same that we used in the reduced form estimations. The first-stage details (FM coefficient with the standard error) are presented below the main regressions results.[15]

The skill shortages measure (share of firms in an industry, reporting to be constrained by labour) ranges from 0 to 1. The coefficient of interest thus represents log point change in dependent variables when skill shortages increase by 1 unit (100%). A one percentage point increase in skill shortages caused by the EU15 labour market opening thus leads to a 1.6-3% drop in firm TFP (depending on the measure) and a 3% increase in personnel costs. Again as in the reduced-form estimations, more productive innovating and foreign-owned companies do not experience significant decreases in TFP, but raise their employee expenses and increase capital intensity.

[15]The reported first-stage coefficients might differ slightly from those reported in Table 7, since some industry-year observations were dropped due to missing firm-level data.

7 Robustness

7.1 Exogeneity assumption

The identification of the skill shortages effect builds on the exogeneity assumption of the constructed instrumental variable. Variation in the Free Movement variable comes from changes in legislation, bilateral distances, and skill shortages in destinations. All three components are determined on the industry level for *old* EU member states and hence should be exogenous to country-industry-year productivity shocks or changes in other unobservables in *new* EU member countries. As a robustness check for the validity of our IV approach, we ran the first-stage regression (8) on another variable, which also varies at the country-industry-year level, but, in contrast to skill shortages, should not systematically react to changes in EU labour mobility legislation. In the EU Business Survey, apart from skill shortages, firms also report on financial constraints. Table 9 presents first-stage regression results with financial constraints as a dependent variable. While for skill shortages all four IV modifications returned statistically significant coefficients, only one of them is weakly correlated with reported financial constraints. This result reassures that the constructed IV captures labour supply shrinking due to emigration instead of other contemporaneous shocks.

7.2 Using different lags of the instrument

In our main specification, we have looked at the effects of emigration on firm performance one year after the respective labour market opening. We have chosen a one-year lag because we expect the effects to kick in with a certain delay, for instance due to the decision making process to migrate, the migration preparation process and the notice period. In the following, we are now looking at simultaneous effects as well as the effects up to three years before and after the sector opening.

Figure 1 shows different firm outcomes that are regressed on lagged (1, 2 and 3 year lag), simultaneous and forwarded (1, 2 and three year forward) FM values. One can see that the forwarded values are almost always insignificantly different from zero. This is reassuring for us, as we do not want the future sector openings to affect current firm outcomes (for instance due to anticipation).[16] If we focus on TFP, the free movement already kicks in during the same year of the opening. Both measures (L&P and index) are negative but only L&P is significant due to the large standard errors of the index.

[16] With the exception of labour productivity as measured by output over wage-adjusted labour.

The effect becomes stronger and more significant after one year and then remains at this lower level during the following two years.

The capital-labour ratio becomes significant only with a delay of two years. This makes sense if we assume that firms need time to adjust their capital. Wages, being much more flexible as capital, adjust instantaneously. During the year and the year following the sector opening, wages (measured by personnel costs) increase significantly. This is likely due to retention measures, increased hiring and training costs and a strategy to attract the best workers. However, in the following two years, wages are declining probably due to reduced productivity. As we do not have a dynamic model, we do not want to over-interpret these results.

8 Conclusion

This paper uses firm- and industry-level panel data to evaluate the effect of skilled emigration on firm productivity. To overcome the endogeneity bias, we exploit the natural experiment setting of the EU enlargements in 2004 and 2007. We argue that the gradual and industry-specific opening of the EU labour markets to citizens from new member states throughout 2004-2014 has created exogenous variation in the emigration rates experienced by EU10 countries.

We show that an emigration-driven reduction in labour supply resulted in lower total factor productivity of EU10 firms due to a loss of firm specific human capital. We also document an increase in personnel costs and training of employees. Furthermore, we find that more productive innovating and foreign-owned firms increased their personnel costs by more and experienced smaller drops in productivity. These firms have been more successful in adjusting to higher labour mobility, in particular, in retaining and attracting better qualified workers.

Our results are important both for firms and for policy makers. Being aware of the problem helps firms to react timely and in an adequate way. Firms can benefit from active human resource strategies, focusing, for instance, on providing training and retention measures. For policy makers, the effects of migration "are not a matter of fate, to a large extent, they depend on the public policies adopted in the receiving and sending countries"[17]. The prevalence of skill shortages, for instance, justifies the need to invest in the skills of their local labour force and to mitigate search frictions. A skill upgrading of the local labour force can in the short-term be addressed by providing specific training

[17]Docquier and Rapoport (2012).

courses by public institutions and in the long-term by adjusting the education system to labour market needs. Knowing that those skilled people are needed 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 emmigrate (Beine et al. (2001)).

While the outflow of skilled workers leads to deteriorating firm performance in the short term, emigration can also create opportunities and countries can experience brain gain if they put in place the right policies. One possibility for brain gain is return migration. If companies and politicians in the new EU member states succeed in bringing back their skilled workers after some time abroad, then firms could benefit from even more experienced workers. These workers can create knowledge spillovers and bring their firms closer to the technological frontier. Another opportunity is to attract workers from other EU member states. An efficient labour agency, and especially harmonized EU-wide labour agencies, could inform workers within the EU of all EU-wide job vacancies. This might encourage unemployed workers in other EU states to search for a job in countries and industries that experience shortages. By attracting workers from other EU countries and incentivised return migration, firms in new member states could also reap the benefits of labour migration in an enlarged Europe.

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9 Appendix

9.1 Solution to the Model, Cobb-Douglas Production Function

We assume a simple Cobb-Douglas production function, with two input factors: skilled and unskilled labour (L_s, L_u). Firms face wages w_s and w_u, job destruction rate δ_s, and job matching rate q_s. V_s denotes the number of posted vacancies, c_s - cost of a skilled vacancy, and c_t - costs per hour of training t. For simplicity search and training costs for unskilled labour are set to zero. Firm productivity A directly depends on learning by doing $(\frac{1}{\delta_s})$ and initial training (t) of the skilled workers: $A = (\frac{1}{\delta_s})^{\gamma_\lambda} t^{\gamma_\tau} L_s^{\gamma_\lambda + \gamma_\tau}$

Firms maximize profits, by choosing the number of workers and the initial amount of training:

$$\Pi = AL_s^{\alpha} L_u^{\beta} - L_s w_s - c_s V_s - c_t t q_s V_s - L_u w_u$$

s.t.

$$\frac{V_s}{L_s} = \frac{\delta_s}{q_s}.$$

Set $\kappa = \gamma_\lambda + \gamma_\tau + \alpha$. Assume $\beta \leq 1 - \kappa - \gamma_\tau$. First order conditions give the implicit solution of the model.

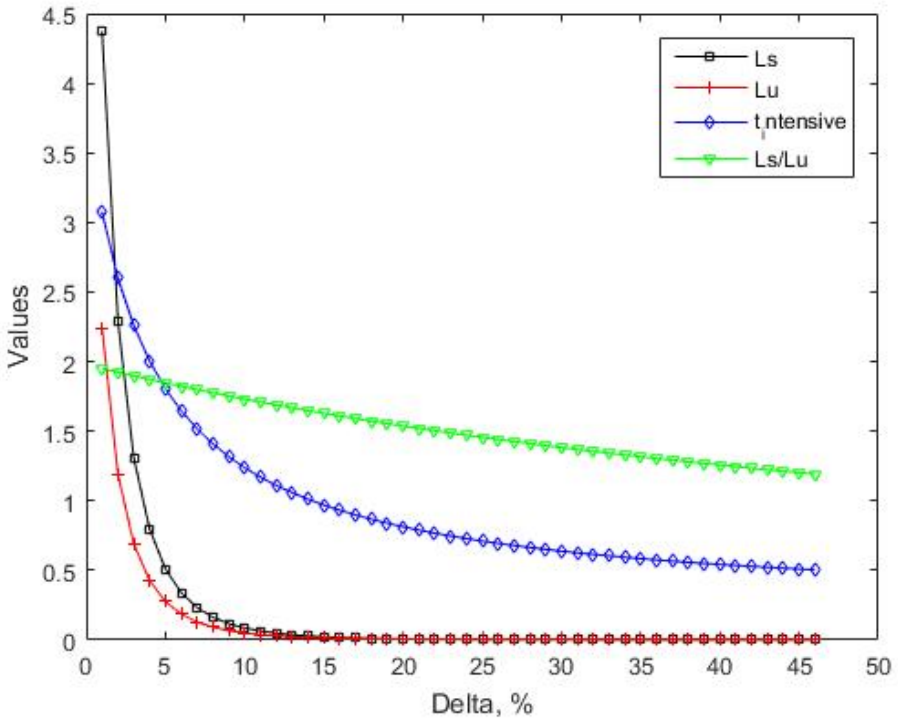
FOC1: $\frac{\partial \Pi}{\partial L_s} = \kappa (\frac{1}{\delta_s})^{\gamma_\lambda} t^{\gamma_\tau} L_s^{\kappa - 1} L_u^{\beta} - w_s - c_t \delta_s = 0$

FOC2: $\frac{\partial \Pi}{\partial L_u} = \beta (\frac{1}{\delta_s})^{\gamma_\lambda} t^{\gamma_\tau} L_s^{\kappa} L_u^{\beta - 1} - w_u = 0$

FOC3: $\frac{\partial \Pi}{\partial t} = \gamma_t (\frac{1}{\delta_s})^{\gamma_\lambda} t^{\gamma_\tau - 1} L_s^{\kappa} L_u^{\beta} - L_s \delta_s c_t = 0$

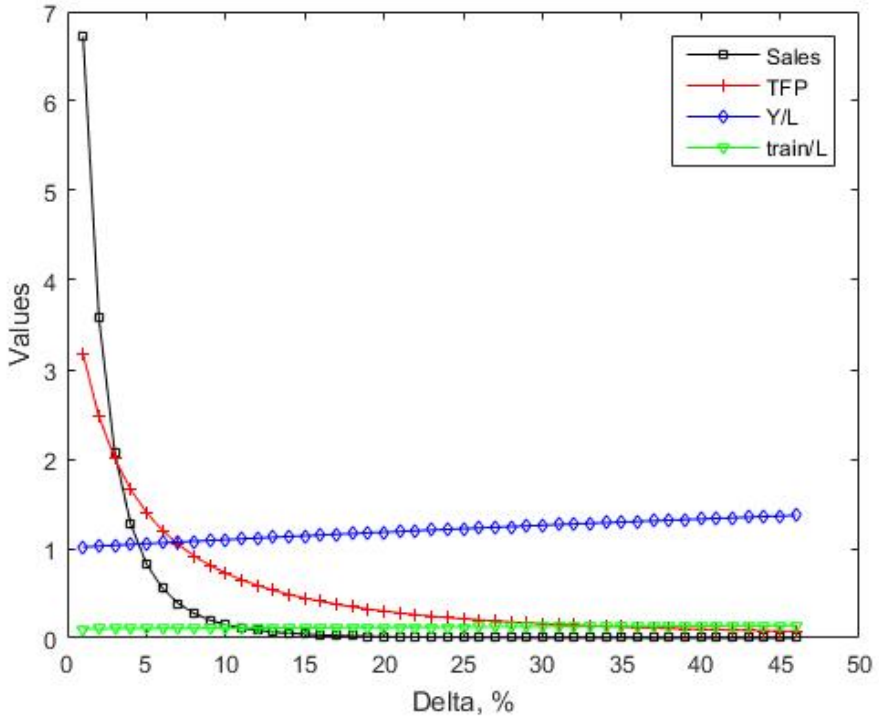
Figures 1 and 2 illustrate the effect of increasing job destruction rate on firm sales, productivity, factor demand, and training.

Figure 1: **Model's solution for different values of job destruction rate (1)**



Note: This graph shows the simulation results of our theoretical framework for different values of delta (the job destruction rate). Ls and Lu stand for skilled and unskilled labour. t intensive describes how much training the workers obtain. Ls/Lu is the ratio of skilled to unskilled labour. We see that for increasing job destruction rates, values of all variables reduce.)

Figure 2: **Model's solution for different values of job destruction rate (2)**



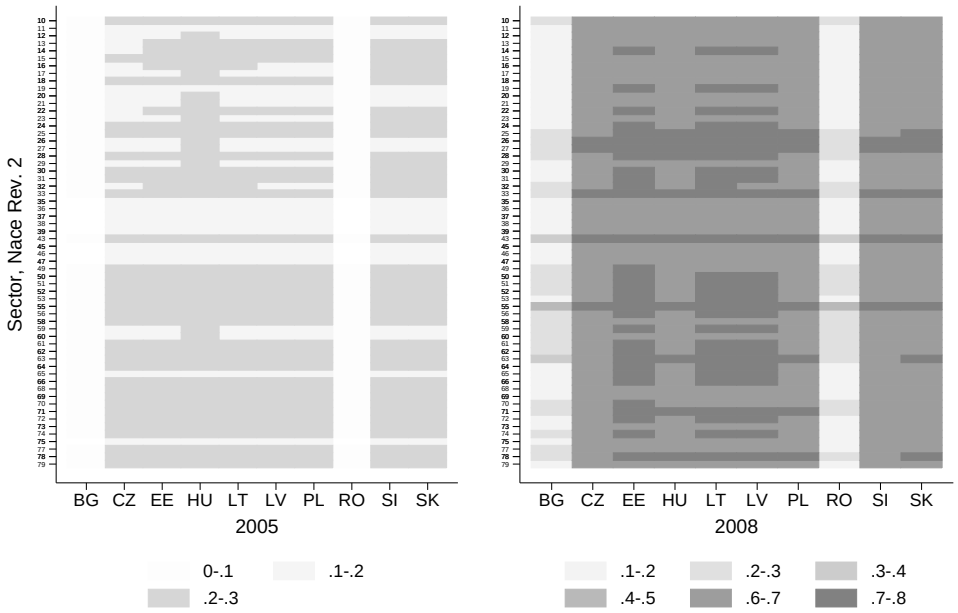
Note: This graph shows the simulation results of our theoretical framework for different values of delta (the job destruction rate). Sales describe the yearly sales of a firm. TFP denotes firm productivity, in the simulation it consists of the workers' learning-by-doing and initial training. Sales and TFP decrease with an increasing job destruction rate. Y/L and train/L describes the output and the training as a percentage of the total labour force. Both increases with an increasing job destruction rate.

9.2 Tables and Figures

Figure 3: **Annual Treatment Effects of Free Movement on Firm TFP**

Note: Dependent variable - firm TFP, estimated with Levinsohn-Petrin procedure. The displayed coefficients correspond to the number of years before and after the largest increase in the Free Movement variable for a given industry. Year, industry, and country-fixed effects are included. Errors are clustered at the country-industry level.

Figure 4: **Variation in the Free Movement Variable**



Note: This graph shows the variation in the instrument. We coompare different industries (y-Axis) in different countries (x-Axis) in 2005 and 2008. The darker the shading, the stronger those industies in those countries have been exposed to emigration.

Table 1: **Summary of Variables**

	(1) Full	(2) Main_sample	(3) Incumbent	(4) Foreign	(5) Hightech	(6) Innovator
Firm-level data:						
number of employees	40.5	65.5	80.0	195	87.1	238
	[305]	[296]	[344]	[554]	[367]	[727]
sales, 000 EUR	3,908	5,554	6,686	26,972	9,954	34,662
	[162,210]	[61,742]	[70,814]	[172,423]	[109,758]	[267,709]
assets, 000 EUR	3,251	4,854	5,735	21,440	7,629	28,953
	[60,287]	[61,480]	[65,025]	[145,629]	[90,648]	[226,421]
firm age	9.16	10.7	13.6	10.8	10.8	14.6
	[8.03]	[7.78]	[7.71]	[8.66]	[7.78]	[9.63]
labour productivity ($\frac{Y}{L}$)	3.47	3.67	3.69	4.28	3.85	4.22
	[1.35]	[1.10]	[1.09]	[1.16]	[1.07]	[0.90]
labour productivity ($\frac{Y}{WL}$)	2.08	1.97	1.94	1.91	1.71	1.80
	[1.08]	[0.89]	[0.85]	[0.92]	[0.89]	[0.71]
TFP index	-0.012	-0.046	-0.050	-0.059	-0.10	-0.15
	[0.89]	[0.67]	[0.68]	[0.63]	[0.63]	[0.55]
Industry-level data, 2 digits:						
FM	0.083	0.13	0.13	0.14	0.19	0.15
	[0.11]	[0.14]	[0.14]	[0.14]	[0.18]	[0.15]
human capital constraints	0.090	0.092	0.10	0.088	0.096	0.12
	[0.11]	[0.11]	[0.12]	[0.11]	[0.12]	[0.13]
financial constraints	0.25	0.18	0.17	0.15	0.13	0.12
	[0.17]	[0.14]	[0.14]	[0.13]	[0.12]	[0.12]
number of employees	11.6	15.4	16.6	22.2	21.7	22.3
	[20.9]	[25.0]	[25.9]	[38.7]	[38.8]	[34.8]
sales, 000 EUR	948	1,033	1,136	2,076	1,911	2,468
	[5,403]	[7,006]	[8,135]	[7,331]	[5,174]	[11,083]
labour productivity ($\frac{Y}{L}$)	4.03	3.79	3.78	4.03	4.05	4.23
	[0.84]	[0.70]	[0.73]	[0.71]	[0.67]	[0.56]
labour productivity ($\frac{Y}{WL}$)	2.21	1.91	1.92	1.91	1.78	1.91
	[0.62]	[0.40]	[0.40]	[0.46]	[0.50]	[0.41]
Observations	3.25e+06	532760	334693	55979	116540	19143
No. of firms	555072	108256	58245	10628	26224	2758

Note: The table reports means and standard deviations (in brackets) of variables used in the regressions. "Full" denotes a sample of all available observations. Further sub-samples don't include observations with missing variables. "Main sample" is a sub-sample of firms used in the main regression. "Incumbent" is a sub-sample of firms that existed prior to 2002. "Innovator" - a sub-sample of firms with patents. "High-tech" - a sub-sample of firms operating in high-tech industries according to Statistical classification of economic activities in the European Community (NACE) at 2-digit level. "Foreign" - a sub-sample of firms with foreign capital.
Productivity measures are reported in natural logarithms.
Constraints are measured as shares of firms in a given industry-country-year reporting to be constrained.
FM is our preferred instrument: the sum of legislation dummies, weighted by proximity measures to a given old EU member-country.
Sources: Amadeus, EU Commission Business Survey, Eurostat Structural Business Statistics

Table 2: **Free Movement Effect on Firm Performance, Reduced Form, Amadeus Data**

	(1) TFP index	(2) TFP LP	(3) ROA	(4) Pers. costs	(5) C/L
$L.FM_{ict}$	-0.273***	-0.234***	-0.0344**	0.270***	0.172
	(0.0696)	(0.0619)	(0.0141)	(0.0628)	(0.106)
$Mark-up_{ict}$	0.212***	0.186***	0.0906***	-0.133***	-0.0824**
	(0.0526)	(0.0350)	(0.0165)	(0.0279)	(0.0404)
$L.log\_investment_{ict}$	0.00178	-0.00707	-0.00556***	0.00521	0.0243**
	(0.00680)	(0.00500)	(0.00203)	(0.00792)	(0.0106)
$L.log\_FDI\_inward_{ict}$	-0.00125	2.82e-05	-0.000435	0.00242	0.00502**
	(0.00143)	(0.00114)	(0.000509)	(0.00148)	(0.00219)
$Log\_total\_sales_{it}$	0.00350	-0.00910	0.000439	0.0516***	0.00880
	(0.0100)	(0.00913)	(0.00262)	(0.00851)	(0.0126)
$Mean\ skill\ sh._{it}$	0.0763	0.160	0.175***	0.0702	-0.0866
	(0.158)	(0.117)	(0.0384)	(0.115)	(0.169)
$L.log\_FDI_{ct}$	0.0123***	0.0108***	0.00231***	0.00819***	0.0113***
	(0.00248)	(0.00226)	(0.000617)	(0.00175)	(0.00229)
$D.log\_GDP_{ct}$	1.520***	1.301***	0.179***	0.397***	0.130
	(0.163)	(0.142)	(0.0443)	(0.0996)	(0.135)
Observations	546,661	322,938	542,500	529,567	529,567
Number of firms	108,413	71,652	107,585	105,572	105,572
R^2	0.074	0.040	0.053	0.105	0.122
Dummies	f y	f y	f y	f y	f y
Clusters	2660	2521	2630	2618	2618

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Note: The table presents reduced-form estimations of the free movement. All specifications are estimated with firm fixed effects and time dummies. Dependent variables: TFP index, TFP LP - tfp estimated with Levinsohn-Petrin procedure, ROA - return on assets, Pers. costs - personnel costs per employee, C/L - capital-labour ratio. L.FM - Free Movement variable (distance-weighted, interacted with skill shortages in destination industries), 1 year lag. Standard errors are clustered on country-industry (NACE 4-digit) level.

Table 3: **Free Movement Effect on Firm Performance, Reduced Form, BEEPS Data**

	(1) TFP index	(2) Wage	(3) Train	(4) New product
$L.FM_{ict}$	-0.541***	0.772	1.706***	-3.589
	(0.083)	(0.620)	(0.577)	(2.772)
$log\_lag\_l_{fict}$	-0.0501	-0.211***	0.0630***	0.0201
	(0.118)	(0.0347)	(0.0170)	(0.0159)
$log\_lag\_sales_{fict}$	0.215**	0.225***	0.0218**	-0.0144*
	(0.107)	(0.0221)	(0.00945)	(0.00831)
$\%\ foreign_{fict}$	-0.187	0.462***	0.179***	0.115
	(0.207)	(0.118)	(0.0637)	(0.0717)
$export\_share_{fict}$	-0.0135	0.0620	-0.105*	-0.0681
	(0.198)	(0.100)	(0.0589)	(0.0707)
Observations	1,344	5,432	5,078	2,179
R^2	0.971	0.227	0.243	0.247
Dummies	cy ci iy	cy ci iy	cy ci iy	cy ci iy
Robust	yes	yes	yes	yes
Clusters	296	591	574	290

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Note: The table presents reduced-form estimations of free movement on firm performance using BEEPS data. All specifications are estimated with country*year (c*y), country*industry(c*i), and industry*year(i*y) fixed effects. Additional firm-level covariates include lagged sales, capital, quadratic terms for firm age and number of employees, share of foreign capital, share of export in sales. $L.FM_{ict}$ represents the sum of legislation dummies, weighted by distance to a given old EU member-country and interacted with skill shortages in destination industries. Standard errors are clustered on country-industry level.

Table 4: **Free Movement Effect on Tenure, Reduced Form, Eurostat Data**

	(1) Mean tenure	(2) Mean tenure	(3) Mean tenure
$F.FM_{ict}$			-0.268
			(0.320)
$L.FM_{ict}$	-0.858***	-1.052***	-1.842***
	(0.144)	(0.219)	(0.272)
$L.log\_investment_{ict}$	-0.110***	-0.0899**	-0.107**
	(0.0389)	(0.0390)	(0.0422)
$log\_total\_sales_{ict}$	0.0261	0.00509	-0.00460
	(0.0907)	(0.0883)	(0.0943)
$L.log\_FDI_{ct}$	-0.172***	-0.148***	-0.166***
	(0.0336)	(0.0320)	(0.0394)
$D.log\_GDP_{ct}$	-1.200	-0.141	-3.564**
	(0.904)	(0.870)	(1.424)
Observations	1,873	1,873	1,564
Number of idc	314	314	312
R^2	0.142	0.136	0.208
Dummies	ic y	ic y	ic y
Clusters	314	314	312

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Note: The table presents reduced-form estimations of free movement on average tenure. All specifications are estimated with industry*country fixed effects and time dummies. L.FM - Free Movement variable, 1 year lag. In specification 1, we use only distance-weighted FM dummies. In specifications 2 and 3, FM dummies are interacted with skill shortages in destination industries. In specification 3, we add a forward lag of the FM variable to check for the absence of pre-trends. Standard errors are clustered on country-industry level.

Table 5: **Free Movement Effect on Firm Performance, Reduced Form, Foreign-Owned Companies**

	(1) TFP index	(2) TFP LP	(3) ROA	(4) Pers. costs	(5) C/L
$L.FM_{ict}$	-0.0571	-0.124	0.0191	0.396***	0.395***
	(0.0796)	(0.0805)	(0.0269)	(0.0642)	(0.110)
$Mark-up_{ict}$	0.105***	0.143***	0.0480***	-0.0509	-0.0546
	(0.0339)	(0.0357)	(0.0136)	(0.0399)	(0.0446)
$L.log\_investment_{ict}$	0.0127*	-0.0108	-0.00692*	-0.0115	-0.0274**
	(0.00768)	(0.00798)	(0.00375)	(0.0110)	(0.0140)
$L.log\_FDI\_inward_{ict}$	4.88e-06	0.000242	-0.000519	0.00119	0.00414
	(0.00170)	(0.00182)	(0.000606)	(0.00139)	(0.00260)
$Log\_total\_sales_{it}$	-0.0114	-0.0245*	-0.00649	0.0509***	0.0302*
	(0.0119)	(0.0130)	(0.00538)	(0.0121)	(0.0171)
$Mean\ skill\ sh._{it}$	-0.103	0.178	0.0425	0.0712	0.0603
	(0.139)	(0.154)	(0.0647)	(0.149)	(0.204)
$L.log\_FDI_{ct}$	0.00938***	0.00639*	0.000382	-0.00195	-0.00690*
	(0.00292)	(0.00347)	(0.00165)	(0.00301)	(0.00394)
$D.log\_GDP_{ct}$	0.809***	0.791***	0.0941	0.196	0.200
	(0.145)	(0.172)	(0.0650)	(0.134)	(0.175)
Observations	56,960	34,354	56,580	55,730	55,730
Number of firms	10,415	6,846	10,361	10,308	10,308
R^2	0.021	0.019	0.016	0.088	0.044
Dummies	f y	f y	f y	f y	f y
Clusters	1683	1489	1668	1670	1670

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Note: The table presents reduced-form estimations of the free movement effect on firm performance, sample is restricted to firms with foreign capital. All specifications are estimated with firm fixed effects and time dummies. Dependent variables: TFP index, TFP LP - tfp estimated with Levinsohn-Petrin procedure, ROA - return on assets, Pers. costs - personnel costs per employee, C/L - capital-labour ratio. L.FM - Free Movement variable (distance-weighted, interacted with skill shortages in destination industries), 1 year lag. Standard errors are clustered on country-industry (NACE 4-digit) level.

Table 6: **Free Movement Effect on Firm Performance, Reduced Form, Firms with Patents**

	(1) TFP index	(2) TFP LP	(3) ROA	(4) Pers. costs	(5) C/L
FM	-0.0702	-0.0883	-0.104***	0.256*	0.604***
	(0.127)	(0.109)	(0.0363)	(0.144)	(0.132)
$Mark-up_{ict}$	0.0460	0.125***	0.0103	-0.0768	-0.0220
	(0.0380)	(0.0385)	(0.0126)	(0.0563)	(0.0638)
$L.log\_investment_{ict}$	-0.0156	-0.0245*	-0.00272	0.0251**	0.0440**
	(0.0121)	(0.0139)	(0.00479)	(0.0117)	(0.0184)
$L.log\_FDI\_inward_{ict}$	-0.000839	-0.00584***	-0.000692	0.000865	-0.000384
	(0.00184)	(0.00203)	(0.000740)	(0.00213)	(0.00277)
$Log\_total\_sales_{it}$	-0.0147	-0.0304	0.00435	0.00534	0.00906
	(0.0180)	(0.0189)	(0.00715)	(0.0162)	(0.0252)
$Mean\ skill\ sh._{it}$	0.0703	0.284	0.0201	0.239	-0.110
	(0.154)	(0.193)	(0.0644)	(0.166)	(0.226)
$L.log\_FDI_{ct}$	0.00130	0.00194	0.00176	0.0128***	0.0151***
	(0.00351)	(0.00450)	(0.00167)	(0.00292)	(0.00398)
$D.log\_GDP_{ct}$	0.383	0.263	0.0656	-0.00291	-0.474*
	(0.253)	(0.252)	(0.0700)	(0.250)	(0.274)
Observations	20,526	13,276	20,507	19,694	19,694
Number of firms	2,812	2,165	2,812	2,769	2,769
R^2	0.113	0.037	0.120	0.128	0.266
Dummies	f y	f y	f y	f y	f y
Clusters	843	729	843	832	832

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Note: The table presents reduced-form estimations of the free movement effect on firm performance, sample is restricted to firms with foreign capital. All specifications are estimated with firm fixed effects and time dummies. Dependent variables: TFP index, TFP LP - tfp estimated with Levinsohn-Petrin procedure, ROA - return on assets, Pers. costs - personnel costs per employee, C/L - capital-labour ratio. L.FM - Free Movement variable (distance-weighted, interacted with skill shortages in destination industries), 1 year lag. Standard errors are clustered on country-industry (NACE 4-digit) level.

Table 7: **First Stage Regression. Effect of Free Movement on Skill Shortages**

	(1) FM, dist	(2) FM*skill sh., dist	(3) FM, migr	(4) FM*skill sh., migr
FM_{ict}	0.0522*	0.125***	0.0767***	0.112***
	(0.0298)	(0.0461)	(0.0144)	(0.0376)
$L.log\_investment_{ict}$	0.00644	0.00650	0.00400	0.00604
	(0.00451)	(0.00455)	(0.00447)	(0.00446)
$Log\_total\_sales_{it}$	0.0105	0.00993	0.0109	0.00912
	(0.00929)	(0.00914)	(0.00916)	(0.00885)
$Mean\ skill\ sh._{it}$	0.200**	0.165*	0.206**	0.148*
	(0.0905)	(0.0875)	(0.0891)	(0.0879)
$L.log\_FDI_{ct}$	0.00145***	0.00148***	0.00134***	0.00148***
	(0.000484)	(0.000483)	(0.000480)	(0.000482)
$D.log\_GDP_{ct}$	0.368***	0.372***	0.387***	0.377***
	(0.0807)	(0.0794)	(0.0812)	(0.0802)
Observations	2,069	2,069	2,069	2,069
Number of pp	428	428	428	428
R^2	0.349	0.352	0.357	0.355
Dummies	ci y	ci y	ci y	ci y
Clusters	428	428	428	428
Fstat	3.081	7.332	28.40	8.859
pval	0.0799	0.00704	1.60e-07	0.00308

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Note: The table presents reduced-form estimations of free movement on skill shortages. All specifications are estimated with industry*country fixed effects and time dummies. Dependent variable: % of firms reporting skill shortages. FM - Free Movement variable. In specifications 1 and 2, we use distance-weighted FM dummies, in 3 and 4 - weights with migration stocks. In specifications 2 and 4, FM dummies are in addition interacted with skill shortages in destination industries. Standard errors are clustered on country-industry level.

Table 8: **Skill Shortages as the Consequence of the Free Movement, 2SLS Regressions**

	(1) TFP index	(2) TFP LP	(3) ROA	(4) Pers. costs	(5) C/L
L.skillsh.	-3.071*	-1.635***	-0.281	3.042**	2.127
	(1.631)	(0.595)	(0.187)	(1.315)	(1.872)
$Mark-up_{ict}$	0.330***	0.308***	0.119***	-0.0106	0.0247
	(0.106)	(0.0647)	(0.0230)	(0.0594)	(0.0670)
$L.log\_investment_{ict}$	0.0298	0.00582	-0.00426	-0.0161	0.00814
	(0.0216)	(0.0101)	(0.00263)	(0.0179)	(0.0224)
$L.log\_FDI\_inward_{ict}$	-0.00338	-0.00171	-0.000652	0.00275	0.00381
	(0.00331)	(0.00193)	(0.000475)	(0.00271)	(0.00362)
$Log\_total\_sales_{it}$	0.0102	-0.00712	0.00135	0.0361*	-0.00400
	(0.0226)	(0.0140)	(0.00370)	(0.0211)	(0.0200)
$Mean\ skill\ sh._{it}$	0.977*	0.654***	0.260***	-0.826**	-0.702
	(0.562)	(0.231)	(0.0665)	(0.403)	(0.706)
$L.log\_FDI)ct$	0.0311**	0.0238***	0.00384**	-0.0100	-0.00219
	(0.0136)	(0.00705)	(0.00150)	(0.0116)	(0.0147)
$D.log\_GDP_{ct}$	1.375***	1.236***	0.221***	0.211	-0.0718
	(0.237)	(0.162)	(0.0510)	(0.249)	(0.240)
Observations	501,277	291,346	497,393	486,190	486,190
Number of firms	88,370	54,965	87,651	86,960	86,960
Dummies	y f	y f	y f	y f	y f
Robust	yes	yes	yes	yes	yes
Clusters	2377	2210	2345	2361	2361
fs_coef	0.0988	0.147	0.0981	0.0985	0.0985
fs_se	0.0423	0.0463	0.0424	0.0435	0.0435

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Note: The table presents estimations of the skill shortages effect on firm productivity. All specifications are estimated with firm fixed effects and time dummies. Dependent variables: TFP index, TFP LP - tfp estimated with Levinsohn-Petrin procedure, ROA - return on assets, Pers. costs - personnel costs per employee, C/L - capital-labour ratio. L.FM - Free Movement variable (distance-weighted, interacted with skill shortages in destination industries), 1 year lag. Standard errors are clustered on country-industry (NACE 4-digit) level. $Firststage\_coef$ is the first-stage coefficient of the instrument and $Firststage\_se$ is the standard error.

Table 9: **First Stage Regression (Robustness). Effect of Free Movement on Financial Shortages**

	(1) FM, dist	(2) FM*skill sh., dist	(3) FM, migr	(4) FM*skill sh., migr
FM_{ict}	0.0791	-0.0414	-0.00399	-0.0800**
	(0.0535)	(0.0553)	(0.0274)	(0.0364)
$L.log\_investment_{ict}$	0.00126	0.00115	0.00131	0.00141
	(0.00638)	(0.00643)	(0.00654)	(0.00637)
$Log\_total\_sales_{it}$	0.00508	0.00522	0.00502	0.00601
	(0.0114)	(0.0115)	(0.0115)	(0.0113)
$Mean\ skill\ sh._{it}$	-0.0551	-0.0342	-0.0476	-0.00650
	(0.0970)	(0.0999)	(0.0967)	(0.102)
$L.log\_FDI_{ct}$	-0.000566	-0.000595	-0.000579	-0.000608
	(0.000508)	(0.000506)	(0.000512)	(0.000507)
$D.log\_GDP_{ct}$	-0.381***	-0.393***	-0.391***	-0.400***
	(0.0747)	(0.0730)	(0.0769)	(0.0734)
Observations	2,070	2,070	2,070	2,070
Number of pp	428	428	428	428
R^2	0.075	0.074	0.073	0.076
Dummies	ci y	ci y	ci y	ci y
Clusters	428	428	428	428
Fstat	2.184	0.561	0.0213	4.832
pval	0.140	0.454	0.884	0.0285

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

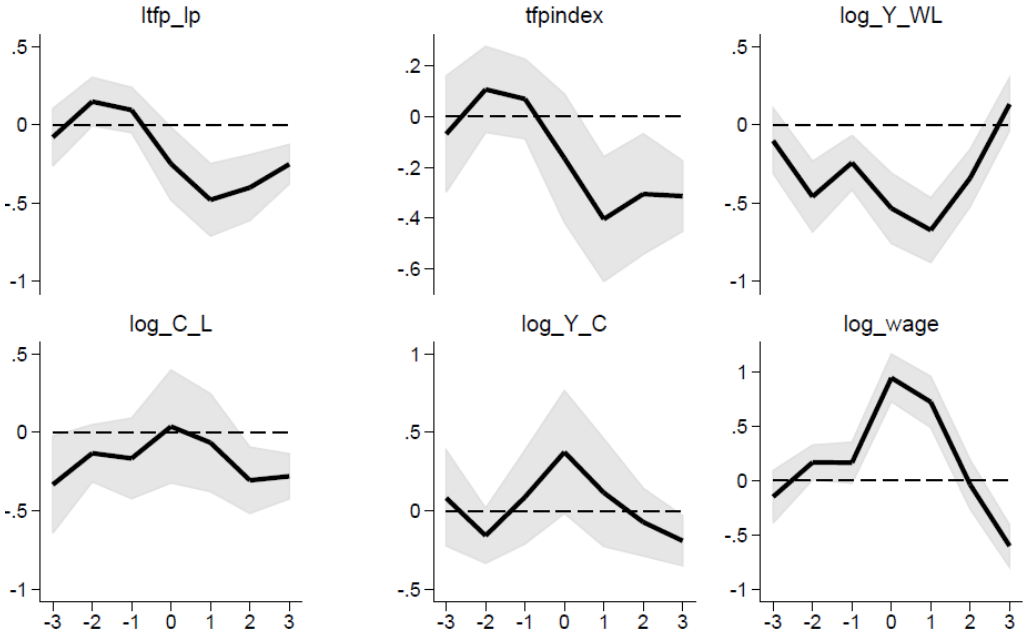
Note: The table presents reduced-form estimations of free movement on skill shortages. All specifications are estimated with industry*country fixed effects and time dummies. Dependent variable: % of firms reporting skill shortages. FM - Free Movement variable. In specifications 1 and 2, we use distance-weighted FM dummies, in 3 and 4 - weights with migration stocks. In specifications 2 and 4, FM dummies are in addition interacted with skill shortages in destination industries. Standard errors are clustered on country-industry level.

Table 10: **Overview of the gradual opening of the EU15 labour markets**

Country	EU8	EU2	Sectoral Exceptions
Austria	2011	2014	EU8 (2007-2010), EU2 (2007-2013): Construction, Manufacturing of electronics and metals, Food and beverage services (restaurant business), other sectors with labour shortages
Belgium	2009	2014	-
Denmark	2009	2009	-
Finland	2006	2007	-
France	2008	2014	EU8 (2005-2007), EU2 (2007-2013): Agriculture, Construction, Accommodation and food services (tourism and catering), other sectors with labour shortages
Germany	2011	2014	EU8 (2004-2010), EU2 (2007-2013): sectors with labour shortages
Greece	2006	2009	-
Iceland	2006	2012	-
Ireland	2004	2012	-
Italy	2006	2012	EU8 (2004-2005): sectors with labour shortages; EU2 (2007-2011): Agriculture, Construction, Engineering, Accommodation and food services (tourism and catering), Domestic work and care services, other sectors with labour shortages; Occupations: managerial and professional occupations
Luxembourg	2008	2014	EU2 (2007 - 2013): Agriculture, Viticulture, Accommodation and food services (tourism and catering)
Netherlands	2007	2014	EU8 (2004-2006), EU2 (2007-2013): International transport, Inland shipping, Health, Slaugther-house/meet-packaging, other sectors with labour shortages
Norway	2009	2012	EU8 (2004-2008), EU2 (2007-2011): sectors with labour shortages
Portugal	2006	2009	-
Spain	2006	2009	Reintroduction of restrictions for Romanians: 11/08/2011 - 31/12/2013
Sweden	2004	2007	-
United Kingdom	2004	2014	EU2 (2007-2013): Agriculture, Food manufacturing

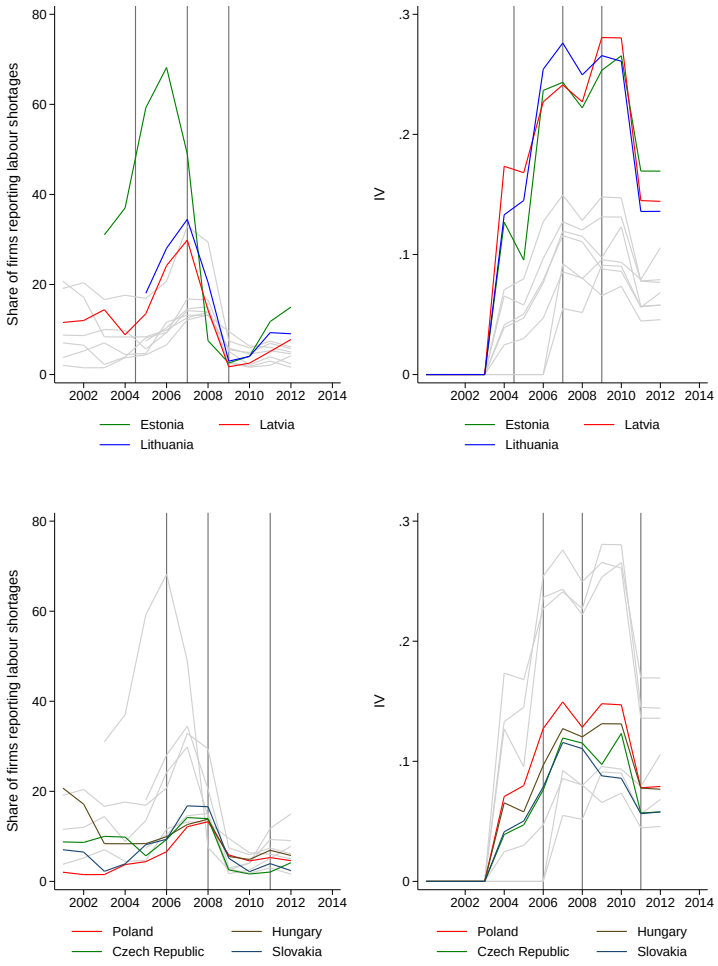
Note: Column 2 shows the year of the labour market opening of the respective country for the EU8 countries, column 3 shows the year of the labour market opening of the respective country for the EU2 countries. Column 4 shows, which sectors were exempt from restrictions. Source: European Commission.

Figure 5: **Dynamic effects (lagging and forwarding the instrument)**



This graph shows the coefficients of the L&P TFP measure, the TFP index, wage-adjusted labour productivity, the capital labour ration, capital productivity and personnel costs when the instrument is lagged, simultaneous or forwarded by up to three years. The 0 value on the x-axis indicates the year of the labour market opening and the values 1,2,3 are the years following the opening, while the values -3,-2 and -1 are the years preceding the sector openings.

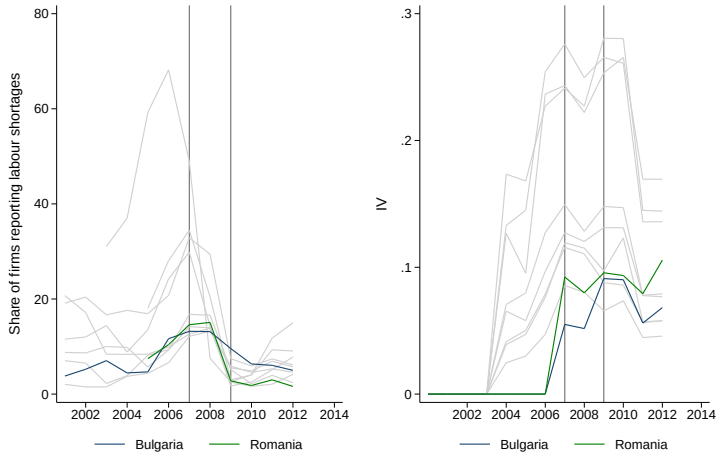
Figure 6: **Aggregate Skill Shortages and FM value in EU8 countries**



Source: EU Commission Business Survey, own calculations

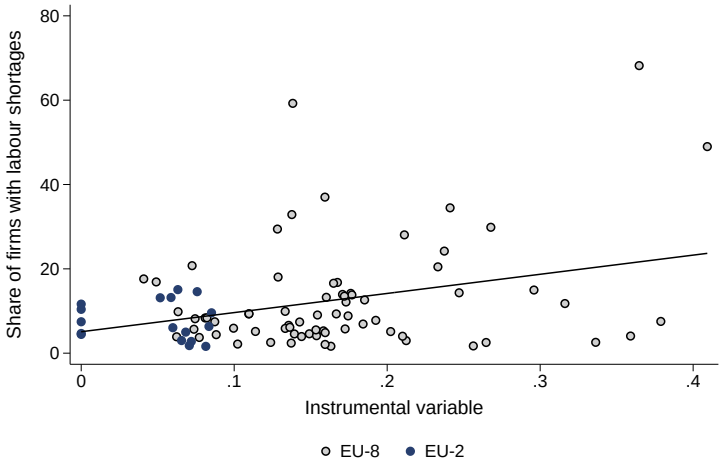
Each dot represents a country-year observation. Industry-level values of skill shortages and IV (FM variable) are aggregated on a country-level proportionally to the number of firms in each industry.

Figure 7: **Aggregate Skill Shortages and FM value in EU2 countries**



Source: EU Commission Business Survey, own calculations
Each dot represents a country-year observation. Industry-level values of skill shortages and IV (FM variable) are aggregated on a country-level proportionally to the number of firms in each industry.

Figure 8: **First stage illustration**



Source: EU Commission Business Survey, own calculations.
skill shortages and FM (instrumental) variable are aggregated on a country-level proportionally to the number of firms in each industry.

9.3 TFP Index Calculation

We calculate TFP index, following Gorodnichenko and Schnitzer (2013), according to the formula below:

$$TFP_{fict} = \hat{y}_{fict} - s_{ic}^{L}\hat{l}_{fict} - s_{ic}^{K}\hat{k}_{fict} - s_{ic}^{M}\hat{m}_{fict} \tag{9}$$

where $\hat{y}_{fict}, \hat{l}_{fict}, \hat{k}_{fict}, \hat{m}_{fict}$ are log deviations of a firm's output, labour, capital, and materials from industry's averages. The latter are calculated on a four-digit industry level (for each country), by taking geometric means across all firm-year observations.

By using deviations instead of levels, we exclude time-invariant country-industry fixed effects and make the index more comparable across different industries and countries.

$s_{ic}^{L}, s_{ic}^{M}, s_{ic}^{K}$ are cost shares of labour, materials, and capital, which are computed for each firm-year and then also aggregated on a four-digit industry level for each country.

As a proxy of output we use firms' sales, labour - wages and salaries, capital - fixed assets, and material - materials' costs. We should note that the obtained TFP index contains not only firms' unobserved technology and management ability, but also firms' market power, and differences in their workforce composition.