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Abstract

In order to foster innovation and enhance economic development and growth, attracting skilled professionals from abroad has become an important policy goal in many economies, initiating a global race for talent. This paper looks at the private company sector in a group of 13 old EU Member States and examines the role of high-skilled third-country (HS-TC) migrants for innovation – as captured by real labour productivity and total factor productivity (TFP) growth – between 2004 and 2015. It utilises four different indicators of HS-TC migration and defines high skills in terms of either educational attainment (ISCED classification) or the skills required in an occupation (ISCO classification) which helps identify the presence of a jobs-skills mismatch for HS-TC migrants. Taking into account the endogenous nature of HS-TC migration, we find some selective evidence of a negative causal link between the share of HS-TC migrants, on the one hand, and labour productivity and TFP growth, on the other. Furthermore, differences in the results for the ISCED- and ISCO-based skills measures point to a non-negligible jobs-skills mismatch in terms of an over-representation of HS-TC migrants in lower productivity occupations. We also find that HS-TC migrants are relatively less productive than HS EU migrants. Results for selected individual industries are more mixed, with some industries even benefiting in productivity terms from a higher share of HS-TC migrant workers.

Keywords: high-skilled third-country migrants, innovation, EU, real labour productivity growth, total factor productivity growth

JEL classification: O15, F22, D24

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Annex

1. Introduction

Skilled migration is seen as an important source of innovation and economic performance and has therefore attracted considerable academic and policy attention. Generally, the effect of skilled migration on the host country's innovative performance can be twofold: First, a direct effect through migrants' skills, which increase the host country's human capital stock, raise its level of creative potential and capacity, and extend its range of exploitable capabilities for innovation. Second, an indirect spillover effect through the transfer of knowledge from migrant workers to native workers in the host country.

In view of this, attracting skilled professionals from abroad has become an important policy objective in many economies, initiating what has been labelled the 'global race for talent' (Chambers et al., 1998). In this context, the EU launched the EU Blue Card Initiative in 2009 (see Council Directive 2009/50/EC)[1] which should allow high-skilled third-country (HS-TC) nationals – that is high-skilled nationals from non-EU Member States - to work and live in all EU Member States.[2] It thereby recognises the important role played by legal migration for the enhancement of the knowledge-based economy in Europe and the advancement of economic development, growth and job creation.[3] The importance of migration for the EU was further underscored by Juncker's Political Guidelines for the European Commission (July 2014)[4], which emphasises the need for a new European policy on legal migration to help the EU address and better deal with its challenges, such as an aging society and the shortage of specific skills. In view of the EU's comparatively limited attractiveness, this policy seeks to make it '*at least as attractive as the favourite migration destinations such as Australia, Canada and the USA*' (Political Guidelines for the European Commission, p. 11).

Furthermore, as one target of the European Innovation Union (IU), Commitment/action point 30 also alludes to this, emphasising the need to '*put in place integrated policies to ensure that leading academics, researchers and innovators reside and work in Europe and to attract a sufficient number of highly skilled third country nationals to stay in Europe*'[5].

Against this background, the ensuing analysis looks at the group of HS-TC migrants, who only more recently attracted policy interest. We focus on the private company sector in a group of 13 old EU Member States (EU-13), which generally attracts the majority of HS migrants, both from the EU (EU migrants) as well as from outside (TC migrants), and is therefore the key beneficiary of migrants' skills and capabilities, also in terms of creative and innovative potentials. In this study, we look at four different indicators of HS-TC migration for two different skills classifications (ISCED and ISCO) for the period 2004 to 2015. The distinction between ISCED and ISCO-based skills measures allows us to identify the

1 See: http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32009L0050&from=EN.

2 Except for Denmark, Ireland and the United Kingdom, which opted-out from its application.

3 For an assessment of the implementation of individual provisions of the directive by individual EU Member States and a discussion of recommendations, see: http://ec.europa.eu/transparency/regdoc/rep/1/2014/EN/1-2014-287-EN-F1-1.Pdf.

4 See: https://ec.europa.eu/commission/sites/beta-political/files/juncker-political-guidelines-speech_en.pdf.

5 See: http://ec.europa.eu/research/innovation-union/pdf/state-of-the-union/2015/state_of_the_innovation_union_report_2015.pdf#view=fit&pagemode=none.

presence and effects of jobs-skills mismatch of HS-TC migrants on labour productivity growth and TFP growth at the sectoral level.

Our empirical analysis points to rather mixed – and only selectively statistically significant – effects and finds evidence of a non-negligible job-skills mismatch for HS-TC migrants. For the overall sample, irrespective of the skills classification used (ISCED or ISCO), the share of HS-TC migrants (in different workforce populations) is statistically unrelated to real labour productivity growth. In contrast, the share of HS-TC migrants in the high-skilled workforce is associated with higher TFP growth, which only holds for the ISCED-based skills measure. In view of this, there is evidence of a jobs-skills mismatch such that HS-TC migrants are more strongly employed in lower level, lower productivity occupations than other high-skilled workers. This underutilisation of their formal educational attainment levels then fails to contribute to higher TFP growth. Once endogeneity between HS-TC migration and measures of productivity is accounted for and causality is clearly established, our results are more consistent but, from a statistical perspective, equally mixed. In particular, a higher share of HS-TC migrants (in different workforce populations) has a partial negative effect on both labour productivity and TFP growth. Differences in results across skills measures again point to a non-negligible jobs-skills mismatch and the over-representation of HS-TC migrants in lower productivity occupations but also indicate that stronger cultural differences and language barriers make HS-TC migrants less productive than other HS EU migrants. For individual industries, our results are more diverse and suggest that while industry H (hotels and restaurants) benefits from a higher share of HS-TC migrants in terms of higher labour productivity and TFP growth, for industries D (manufacturing), J (finance) and K (real estate and business services), a stronger presence of HS-TC migrants is associated with significantly lower labour productivity and/or TFP growth. A non-negligible jobs-skills mismatch of HS-TC migrants again helps explain observable differences in results across skills measures.

The rest of the paper is structured as follows. Section 2 briefly reviews the literature of the impact of immigration on innovation. Section 3 provides a detailed descriptive account of the presence of HS-TC migrants and the prevalence of a job-skills mismatch for HS-TC in different EU-13 countries and industries. Section 4 presents the underlying methodological framework for the quantitative analysis and discusses results for the total EU-13 sample as well as relevant individual industries, also once the issue of endogeneity is addressed and causality is more clearly established. Finally, section 5 summarises and concludes.

2. Related literature

Following the seminal paper of Dolado et al. (1994), a growing body of empirical literature has looked into the impact of migrant workers on productivity (labour and Total Factor Productivity (TFP)) and on innovation. In general, empirical evidence suggests that the measured effect depends on the unit of analysis and type of migrant considered.

The majority of analyses were conducted at the geographical level, such as country, region, state, province or city, and, with few exceptions, have generally found a positive effect. Boubtane et al. (2014) study the effects of net migration on labour productivity growth in 22 OECD countries and show that migration has a positive, but small, effect on productivity growth: a one percentage point increase in foreign-born net migration increases productivity growth by three-tenths of a percentage point per year on average. Similarly, for a large sample of advanced economies, Jaumotte et al. (2016) show that both a high share of migrants, in general, and a high share of high-skilled as well as low and medium-skilled migrants, in particular, have a labour productivity enhancing effect. For the US, Peri et al. (2015) suggest that foreign science, technology, engineering, and mathematics (STEM) workers contribute to TFP growth in US cities by around 0.5 percentage points per year, while Peri (2012) finds a positive significant relationship between immigration and TFP growth for a sample of 50 US states. In contrast, Ortega and Peri (2009), who study bilateral immigration flows from 74 countries of origin into 14 OECD countries, detect no significant effects of immigrants on TFP changes. Furthermore, following the endogenous growth tradition (Solow, 1957; Romer, 1990; Aghion and Howitt, 1992; Grossman and Helpman, 1991), which emphasises the importance of knowledge formation and technical change for the productivity and growth of economies and attributes a pivotal role to highly skilled workers in this process, scientific attention has increasingly been given to the effects of immigration on innovation. For instance, Hunt and Gauthier-Loiselle (2010) stress the positive contribution of foreign college graduates in the US and calculate that a one per cent increase in immigrant college graduates results in an increase in patents per capita of 9 to 18%. Similarly, Kerr and Lincoln (2010) quantify the impact of changes in H-1B admission levels on the pace and character of innovations in US cities and show that an increase in H-1B admissions substantially increased the rate of innovation, particularly of Indian and Chinese inventors, who were the key beneficiaries of the H-1B visa programme. For Europe, Bosetti et al. (2015) conducted the most comprehensive study in this regard. It uses a panel of 20 European countries and points to a similar positive role of a large pool of skilled migrants on innovation. It estimates that a one per cent increase in the share of skilled migrants increases the number of patent applications and citations to published articles by between 0.1 and 0.3 per cent. However, comparable analyses for individual European countries emphasise that skilled migrants are not necessarily associated with more innovation and patenting. While Gagliardi (2015) finds a positive effect of skilled migration on product and process innovation in British (travel to work) areas, Bratti and Conti (2017) fail to find any evidence in Italian provinces of any innovation-enhancing effect of immigration, in general, or medium-high-skilled immigration, in particular.

In contrast, the few existing sectoral studies indicate that effects strongly depend on the type of migrant – in terms of skills or educational attainment – and industry – in terms of technology intensity. Huber et al. (2010) analyse the effects of high-skilled migrants on TFP growth in the group of old EU Member States and point to positive effects of migrant shares – particularly of high-skilled migrants – on TFP growth in the group of industries which require higher levels of educational attainment but to no effects in the group of industries which require low levels of educational attainment. Similarly, Fassio et al. (2015) show for the three largest European countries (France, Germany and the UK) that highly educated migrants have a larger positive effect on TFP growth in high-tech sectors, while middle and low educated migrants are more important for TFP growth in manufacturing.

Finally, firm level analyses suggest that what matters for the innovativeness of firms is the ethnic and cultural diversity in research personnel instead of its size and the general business and country context in which firms operate. Trax et al. (2012) exploit detailed information for German plants and demonstrate that TFP gains are unrelated to the share of foreign employees in the total workforce. In contrast, Ozgen et al. (2013) find a negative effect and show that Dutch firms in which foreigners account for a larger share of employment are less likely to be innovative.

3. Descriptive analysis

In this section we provide a descriptive analysis of how high-skilled third-country migrants (HS-TC migrants) affect productivity growth in EU-13 economies.[6]

The database used for this analysis is, firstly, the EU Labour Force Survey (EU LFS) from which we could extract information regarding HS-TC migrants and other labour force information. Unfortunately, the (anonymised) EU LFS only provides data at the crude NACE 1-digit industry level and this constrained the analysis. Furthermore, in order to account for the NACE-classification break between 2008 and 2009, we reclassified all NACE Rev. 2 (1-digit) industries to the cruder NACE Rev. 1.1 (1-digit) classification. Secondly, as regards information regarding other industry-level information, particularly on productivity growth and control variables, we used the EU-KLEMS database (EU-KLEMS Productivity and Growth Accounts, 2017), generally available at a more disaggregated industry-level but, for the sake of compatibility with the EU LFS data, it was also reclassified to the cruder NACE Rev. 1.1 (1-digit) level. Since information on the country of origin (by country of birth) in the EU LFS is only available from 2004 onwards and the EU-KLEMS database is available until 2015 only, our analysis refers to the period between 2004 and 2015.

In the following we shall give a first overview of the presence of HS-TC migrants in EU-13 labour markets, by country and by sector over the period 2004-2015 which also amounts to the period over which our econometric analysis was conducted (see section 4). In a second descriptive assessment we shall present some graphs for two sub-periods 2004-2007 and 2008-2015 regarding the relationship between productivity growth and the presence of HS-TC migrants in the EU labour force. Reason for distinguishing these two periods was the break in statistical classification in 2008 at the NACE industry level which did affect our employment data (see Table A.1 in Annex A on the NACE classification used). We have tried to adjust the data as much as possible to obtain 'smooth' time series, but we still distinguish the two periods in the following graphs. The two time periods also roughly coincide with the pre-crisis period and the period following the outbreak of the financial and economic crisis.

Let us first define the various ratios regarding the presence of HS-TC migrants in the employed labour forces of the EU-13 countries. These will be used throughout our analysis (see Figures 1 and 3; 'Panels' refer to these figures):

- Panel A: the share of HS-TC migrants in overall employment
- Panel B: the share of HS-TC migrants in total skilled employed labour force
- Panel C: the share of HS-TC migrants in total migrant employed labour force
- Panel D: the share of HS-TC migrants in total employment of skilled migrants

[6] The EU-13 include all the 'Old Member States (OMS)' that formed the EU prior to the countries that entered following the Enlargement waves in 2004 and 2007. From the 15 OMS, Luxembourg and Finland have been excluded in the following analysis – Luxembourg because of its outlier position as regards non-natives working in that country, and Finland because no data is included in the anonymised microdata.

These different indicators will also be used later on in the econometric analysis.

As concerns the notion of 'highly skilled', we employed two indicators depending upon whether we used ISCED or ISCO classifications, the first one identifies 'highly skilled' by educational attainment levels and the second whether the person is employed in occupations that require higher skills. Hence, the two indicators defining 'higher skilled' include within the ISCED and the ISCO classifications the following categories respectively:

› Highly skilled using ISCED classification includes: ISCED categories 5-8[7]

› Highly skilled using ISCO classification includes: ISCO categories 1-3.

One of the interesting questions we can examine using these two different indicators of 'high skilled' migrants is to see whether the presence of HS-TC migrants in employment differ when one or the other of the two definitions is used. For instance, if we find that the share of HS-TC migrants in high-level occupations is less than the share in high education categories, this could be interpreted in two different ways: (i) there could be a 'skills-occupations mismatch' in the sense that highly educated migrants are under-represented in high-level occupations. Thus the high educational attainment levels of TC migrants are not sufficiently utilised in 'skill adequate' jobs as compared to other groups of workers (HS domestic workers or other EU skilled migrants); or (ii) the fact that the HS-TC migrants get employed at proportionately lower shares in 'high-skill demanding occupations' reflects the fact that formal educational attainment levels as captured by the ISCED categories do not fully reflect differences in 'skills' when it comes to performing in high-level occupational categories. Both these two explanations are in principle possible.

Finally, as regards the indicators of 'productivity' that will be used in the following as proxies for innovation, we shall use two different ones:

› Real labour productivity (at 2010 prices) defined as value added per hour worked

› Total factor productivity (TFP) that is readily available in the EU-KLEMS database.

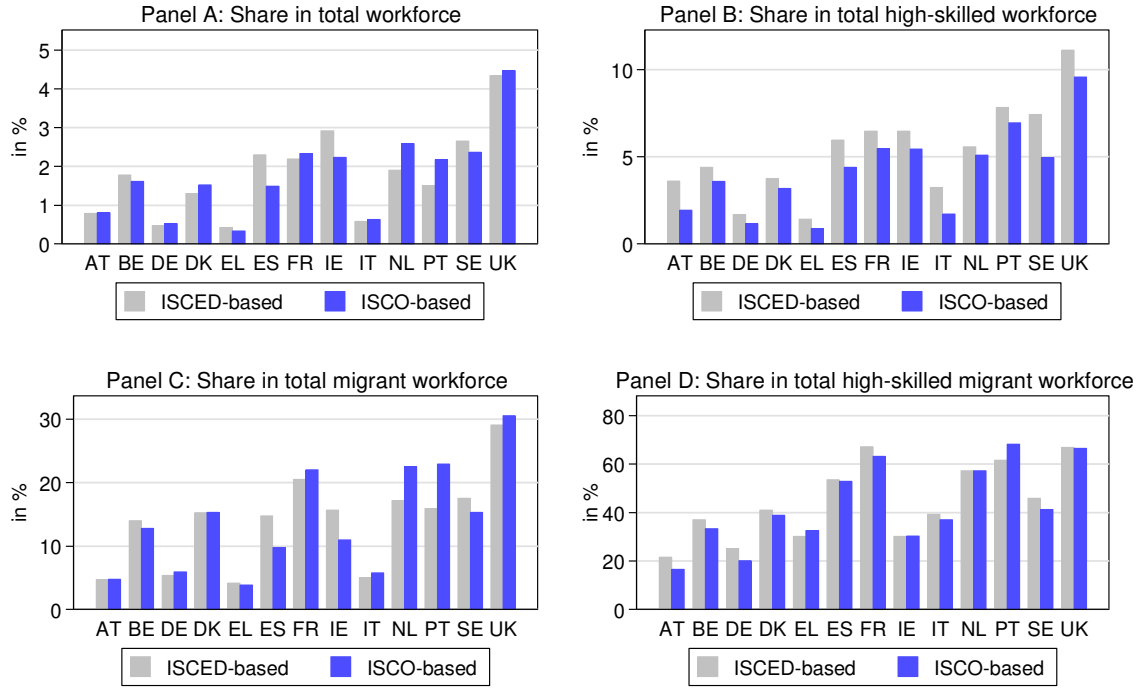
We shortly review the information contained in Figures 1-3: As regards the presence of HS-TC migrants in the different EU-13 countries, we can see (Figure 1; Panel A) that 4 countries have a very small share of HS-TC migrants in their total employed labour forces, i.e. below 1%: Austria, Germany, Greece and Italy. The same countries also show a very small share of HS-TC migrants in the total migrant workforce (Panel C). Hence the evidence is that EU (high skilled) migrants represent a significantly higher share of migrants than third-country (high-skilled) migrants in these countries. The United Kingdom sticks out with by far the highest share of HS-TC migrants in the employed labour force in total (above 4%), and amongst the high-skilled labour force as a whole (around 10%; Panel B). Other countries that either have colonial connections (France, Spain, Netherlands, Portugal) or generally have a high share of migrants (Ireland) or of refugees (Sweden) also show a high share of HS-TC migrants in the overall workforce (around 2%) and amongst the high-skilled labour force as a whole (around 5-7%). As regards

[7] ISCED categories 5 to 8 refer to the following: Short-cycle tertiary education (ISCED 5), Bachelor's or equivalent level (ISCED 6), Master's or equivalent level (ISCED 7) and Doctoral or equivalent level (ISCED 8). ISCO categories 1 to 3 refer to the following: Managers (ISCO 1), Professionals (ISCO 2) and Technicians and associate professionals (ISCO 3).

the shares of HS-TC migrants in overall high-skilled migrants, we see again a rather wide range (Panel D): Austria and Germany with only about 20% or below, while France, Netherlands, United Kingdom, Spain and Portugal rely to between 55% and 65% on HS-TC migrants with the rest being EU migrants. Remember however, that the graphs give a picture for the average of the period 2004-2015. Information regarding changes in these shares can be seen in Figures A.1 and A.2.

As concerns Panel B in Figure 1, the differences between the grey and blue bars reflects the difference in the shares of HS-TC migrants in the total skilled labour force when 'skills' are measured by ISCED (grey bars) or ISCO categories (blue bars). We can see that in all the countries the shares of HS-TC migrants by educational attainment in employment (grey bars) are higher than the shares of HS-TC migrants when we look at their presence in 'high skill demanding jobs' (the blue bars). As discussed above, this indicates a 'skills-jobs mismatch' that can be interpreted in two different ways. This discrepancy is particularly high in Austria where the shares of HS-TC migrants in high-skill jobs is only about half of their shares by educational attainment. The discrepancy is also relatively high in Italy, Sweden and Germany. In Panel D, we can observe this phenomenon in relation to high skilled migrants as a whole. As the other migrants refer to EU migrants we can see here whether a discrepancy exists in terms of 'jobs-skills mismatch' of HS-TC migrants compared to EU migrants. This discrepancy exists in all the more advanced West European EU Member States with the exception of the United Kingdom and the Netherlands, while the Southern EU Member States (Greece, Spain, Portugal, and also Ireland but not Italy) do not show such a disadvantaged job placement situation of HS-TC migrants compared to EU migrants.

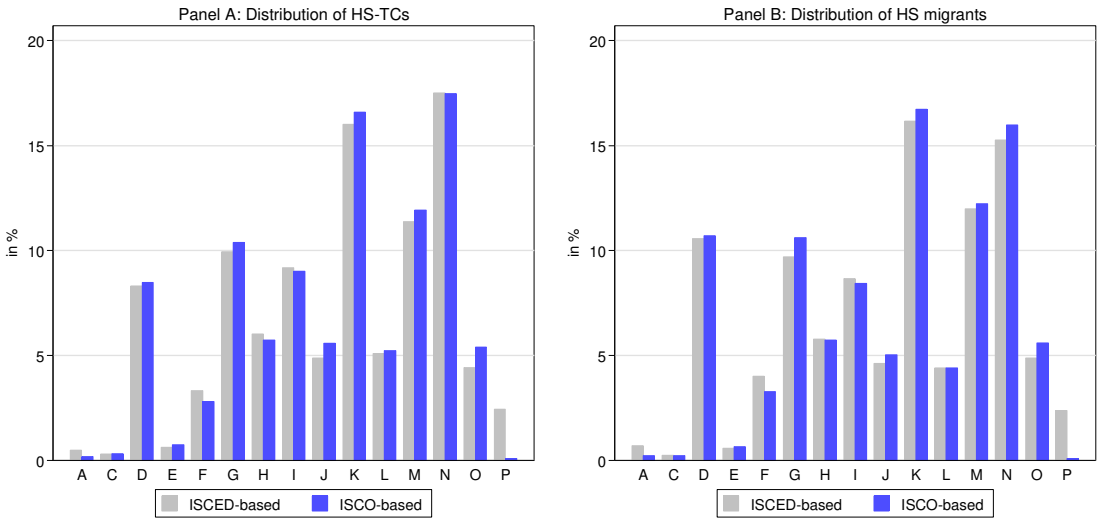
Figure 1 / Share of HS-TC migrants in different workforce groups, by country



Note: ISCED-based (grey bars) refers to highly skilled by educational attainment level while ISCO-based (blue bars) refers to highly skilled by occupations that require higher skills.
Source: EU LFS, own calculations.

We now move on to discuss the presence of HS-TC migrants in different industrial branches (see Figures 2 and 3). As mentioned earlier only a NACE 1-digit breakdown was available to us.[8] First of all, we can see in Figure 2 that industries A (agriculture et al.), C (mining), E (electricity et al.) and P (self-employed et al.) show an insignificant share of employment of HS-TC migrants. On the other hand, industries K (real estate and business services) and N (health and social work) are each employing about 17-18% of the HS-TC migrants in the EU-13 as a whole. Also branches D (manufacturing), G (wholesale and retail trade), H (hotels and restaurants), I (transport and communications), J (finance), L (public administration and social security), M (education), and O (other social and personal services) employ significant shares of HS-TC migrants between 5% and 12%. Furthermore, we see from Figure 2 (Panels A and B) that the distribution of highly skilled migrants across branches does not differ much between HS-TC migrants and other highly skilled migrants.

Figure 2 / Distribution of HS-TC migrants (Panel A) and HS migrants (Panel B) across EU-13 industries



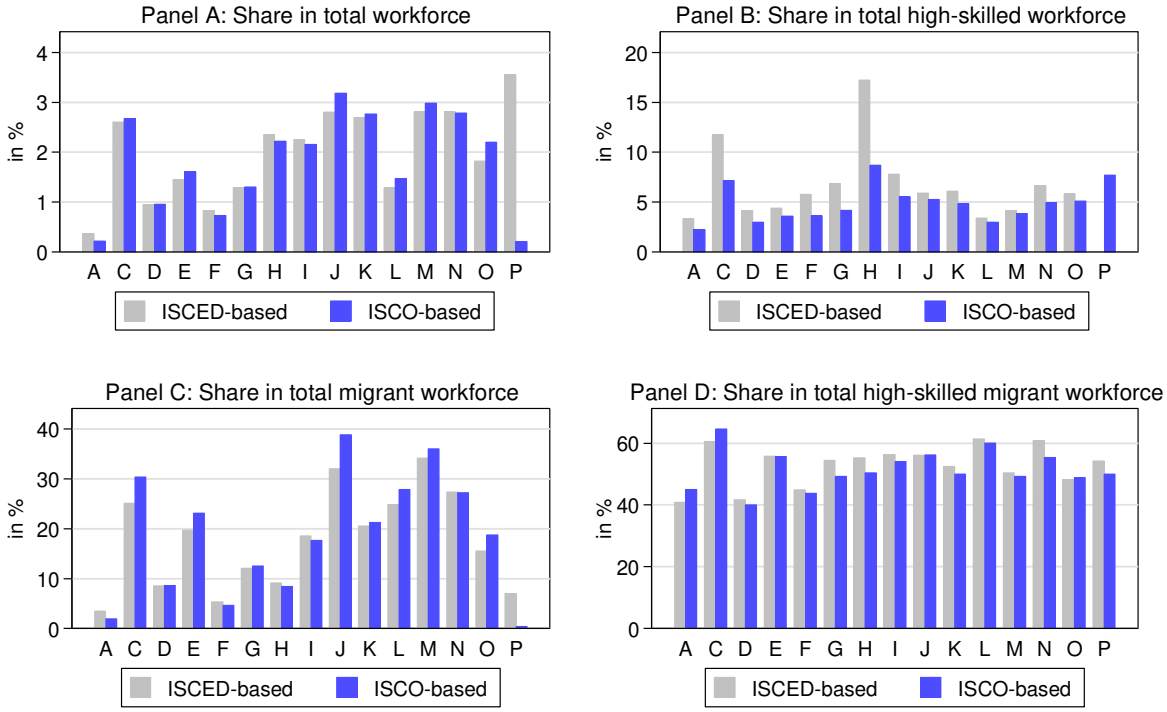
Note: ISCED-based (grey bars) refers to highly skilled by educational attainment level while ISCO-based (blue bars) refers to highly skilled by occupations that require higher skills.
Source: EU LFS, own calculations.

The importance of HS-TC migrants (for EU-13 as a whole) in the different branches are visible in Figure 3, again as a share of total employment (Panel A), as a share of total skilled workforce (Panel B), in total migrant workforce (Panel C; which reflects the skill intensities of the different branches as regards employing highly skilled TC migrants), and as a share of all highly skilled migrants (Panel D). Starting with Panel D: HS-TC migrants represent a high 40-60% of all high-skilled migrants across all the branches. Hence they are a very important group overall, although – as we have seen above – this differs quite strongly across the different EU-13 countries. As a share of the total highly skilled workforces (Panel B) they amount to between 3% and 8% depending upon branch and whether one uses ISCED or ISCO measures. The outlier is industry H (hotels and restaurants) where high-skilled migrants make up 17% and 8% of the HS workforce – the first referring to the ISCED and the second to the ISCO measure. The discrepancy between these two numbers is particularly high in this branch and can again be interpreted as a relatively high share of the highly educated (i.e. half) not working in

[8] For the industry classification by NACE Rev. 1.1 used in this study see Table A.1 in Annex A.

'high-skill demanding jobs' in this industry, i.e. there is significant 'jobs-skills mismatch' in this branch. The tendency for such a mismatch is also visible in all the other branches, but not to the same extent as in industry H.

Figure 3 / Share of HS-TC migrants in different workforce groups, by industry



Note: ISCED-based (grey bars) refers to highly skilled by educational attainment level while ISCO-based (blue bars) refers to highly skilled by occupations that require higher skills.
Source: EU LFS, own calculations.

Let us now move to some examples of developments regarding changes in the shares of HS-TC migrants in employment in some selected branches over the two sub-periods 2004-2007 and 2008-2015. Such changes will be set against changes in labour productivity over the same periods in Figures A.1 and A.2 in preparation of the econometric analysis that will be reported in section 4 below. We chose industries D (manufacturing), I (transport and communications), J (financial intermediation) and K (business services) as illustration of the diversity of developments across branches regarding this relationship. We do not want to interpret much into the figures as we do not control for other factors that affect productivity growth; this will be done in the more detailed econometric analysis that follows. In the econometric analysis we shall also experiment with different specifications, using annual and sub-period interval analysis, therefore dealing with endogeneity issues. At this stage, we mainly want to point out that the relationship between labour productivity growth and changes in employment shares of HS-TC migrants in the two sub-periods appears to be quite diverse (see Figures A.1 and A.2). For illustrative reasons, we show the relationship using two different measures of the presence of HD-TC migrants in the labour force: in Figure A.1 their share in total employment in the selected branches and in Figure A.2 their shares in total highly skilled workforces. This corresponds to Panels A and B respectively in the earlier Figures 1 and 3. Except that we are looking here at changes in these shares in the respective sub-periods. Furthermore, we show again the two different measures of 'skills' i.e. by ISCED categories (Panel A in Figures A.1 and A.2) and by ISCO categories (Panel B in Figures A.1 and A.2).

The main message from these Figures is that the relationship between the change in labour productivity levels and the change in the share of HS-TC migrants shows up to be quite differentiated across branches and also depends on the measure (ISCED or ISCO) used. There are a few negative relationships – i.e. higher increases in labour productivity associated with a low increase (or fall) in the share of HS-TC migrants in these industrial branches. On the other hand, we also find some positive relationships, particularly in industries K (business services) and at times in industry I (transport and communications) depending again on whether ISCED or ISCO measures are being used. We shall leave any interpretation of the results regarding these relationships to the more comprehensive econometric analysis that is now to follow.

4. Quantitative analysis

4.1. METHODOLOGICAL APPROACH

In what follows, we analyse the effects of high-skilled third-country (HS-TC) migrants on two different productivity measures, as proxies for the innovative performance of industries.

First, in order to shed light on the *labour productivity* effects of high-skilled migration from third (non-EU) countries, we estimate a human capital augmented production function, further augmented by four different indicators of high-skilled third-country migration. Since HS-TC migrants bring with them know-how and capabilities that may have an impact on the rate at which productivity changes, we determine the impact of HS-TC migrants on the growth rate of labour productivity. We assume a standard Cobb-Douglas production function, in which all variables are expressed per total-hours-worked, and estimate the following specification:

$$\Delta lnRLPh_{ijt} = \alpha_0 + \beta_1 \Delta lnITCAPh_{ijt} + \beta_2 \Delta lnNITCAPh_{ijt} + \beta_3 \Delta shHS_{ijt} + \beta_4 \Delta shHSTCN_{ijt} + \tau_{it}$$

$$+\varphi_{jt} + \omega_{ij} + \varepsilon_{ijt}$$

where $\Delta lnRLPh_{ijt}$ refers to the growth rate of real labour productivity per total hours worked (at 2010 prices) of industry i in country j at time t. Total capital services are split into ICT and non-ICT capital, whose growth rates (per total hour worked) are captured by $\Delta lnITCAPh_{ijt}$ and $\Delta lnNITCAPh_{ijt}$ respectively. $\Delta shHS_{ijt}$ is the change of the share of highly-skilled employees in the total workforce of industry i in country j and time t. The four different indicators of highly-skilled third-country migration ($\Delta shHSTCN_{ijt}$), which enter our estimations separately to avoid issues of multicollinearity, are as defined above: (i) the change in the share of HS-TC migrants in the total workforce of industry i in country j at time t, (ii) the change in the share of HS-TC migrants in the total high-skilled workforce of industry i in country j at time t, (iii) the change in the share of HS-TC migrants in the total migrant workforce of industry i in country j at time t, and (iv) the change in the share of HS-TC migrants in the total high-skilled migrant workforce of industry i in country j at time t. Finally, τ_{it}, φ_{jt}, ω_{ij} refer to country, industry and time fixed effects, respectively, while ε_{ijt} is the error term.

Second, we also determine the effects of (highly skilled) TC migrants on productivity directly, using **TFP** growth at the industry-level as dependent variable. In particular, we estimate the following specification:

$$\Delta TFP_{ijt} = \alpha_0 + \beta_1 \Delta shMIG_{ijt} + \beta_2 \Delta HStcnHS_{ijt} + \beta_3 \Delta HStcnMIG_{ijt} + \tau_{it} + \varphi_{jt} + \omega_{ij} + \varepsilon_{ijt}$$

where ΔTFP_{ijt} is the TFP growth rate of industry i in country j at time t.

The impact of HS-TC migrants is captured by (i) the change in the share of HS-TC migrants in the total high-skilled workforce of industry i in country j at time t ($\Delta shHStcnHS_{ijt}$) and (ii) the change in the share of HS-TC migrants in the total migrant workforce of industry i in country j at time t ($\Delta shHStcnMIG_{ijt}$) which are the same variables in equation (1) above. However, we also include another variable i.e. (iii)

the change in the share of migrants in the total workforce of industry i in country j at time t ($\Delta shMIG_{ijt}$). This variable is included to capture the differentiated presence of migrants as a whole in different industries. This would otherwise be captured by industry fixed effects. Due to the rather strong correlation between (i) and (ii) – particularly at the industry level – these variables are included separately. Finally, τ_{it}, φ_{jt}, ω_{ij} refer to country, industry and time fixed effects, respectively, while ε_{ijt} is the error term.

Methodologically, to account for unobserved heterogeneity, we estimate both random effects (RE) and fixed effects (FE) models, which differ in the way how unobserved industry heterogeneity is accounted for. Furthermore, we focus on a subset of industries and exclude those industries, whose productivities are difficult to measure accurately and reliably and lie outside the focus of our analysis. In particular, we focus on industries A, C, D, F, G, H, I, J and K (NACE Rev. 1.1) and exclude all public sector industries, such as E, L, M, N, O, P and Q. Estimations are conducted for the total sample of selected – predominantly services – industries as well as for each industry individually, which, in the light of strong industry-heterogeneity, allows us to bring out differences across and specificities of industries more explicitly. Unfortunately, the high level of aggregation of our industry-data does not allow us to differentiate industries by their technology intensity (such as in Huber et al., 2010 or Fassio et al., 2015). As key recipients of HS-TC migrants in the EU, we focus on the group of old EU Member States (OMS), which generally comprises all EU-15 MS except for Luxembourg (for its outlier position) and Finland (for its absence in the anonymised LFS dataset). However, due to the unavailability of TFP growth information for Ireland and Portugal, both countries are absent from the ensuing TFP growth analysis. Furthermore, in the light of potential heteroscedasticity issues, heteroscedasticity-robust t-values are reported.

However, our estimates may be biased due to the endogeneity of the regressor of interest, namely HS-TC migration. In particular, reverse causality may be at play since HS-TC migration helps stimulate innovation in an industry while higher innovation attracts more HS-TC migrants to these industries due to higher expected returns to their skills and education. To address the potential reverse causality bias, we employ interval regressions for three periods, where methodologically, the period-average real labour productivity (or TFP) growth is regressed on the change in the share of HS-TC migrants (in different workforce populations) at the beginning of the period (see section 4.3 below for results). The three periods are defined as follows: (i) period 1: from 2005 to 2007 which not only coincides with the period before the onset of the global financial and economic crisis but also accounts for the break in the statistical classification between 2007 and 2008 (from NACE Rev. 1.1 to NACE Rev. 2), (ii) period 2: 2008-2011, and (iii) period 3: 2012-2015. We again estimate both random effects (RE) and fixed effects (FE) model (with period FE) and report heteroscedasticity-robust t-values.

5. Findings

Results for real labour productivity are reported in Table 1 below for the total EU-13 sample and all relevant industries together, namely A, C, D, F, G, H, I, J and K. Columns (1) to (8) refer to high skills as defined by the ISCED classification while columns (9) to (16) refer to high skills as defined by the ISCO classification.[9] Generally, the results show that, irrespective of classification considered, an increase in the share of HS-TC migrants (either as share in total, high-skilled, migrant or high-skilled migrant workforce) is statistically unrelated to real labour productivity growth. However, in the light of the rather heterogeneous industry sample and the differentiated relationship between real labour productivity growth and the change in the share of HS-TC migrants (see Figures A.1 and A.2 for some selected industries), this finding is not particularly surprising.

Hence, in view of this pronounced heterogeneity, estimations were also run for each industry separately to bring out prevailing differences across industries. Results are reported in Tables B.4 (ISCED-based) and B.5 (ISCO-based) in Annex B. For the sake of brevity, results are only reported for the most skill-intensive industries, namely D (manufacturing), I (transport and communications), J (finance) and K (real estate and business services) as well as H (hotels and restaurants), which is not a particularly skill-intensive industry but stands out in terms of the high share of HS-TC migrants in the total high skilled workforce and the high degree of jobs-skills mismatch (see discussion in section 3). We also excluded industry C (mining) from the individual industry-analysis, where HS-TC migrants only represent a minor fraction (see Figure A.2). Generally, results in Tables B.4 and B.5 show that except for industries D (manufacturing) for both classifications, J (finance) for the ISCED-based skill measure only and H (hotels and restaurants) for the ISCO-based skill measure only, all measures of HS-TC migrant shares are statistically unrelated to real labour productivity growth. In industry D (manufacturing), all four different indicators reflecting the changing presence of HS-TC migrants are negatively related to real labour productivity growth (particularly if based on the ISCO classification). However, this result refers to the overall manufacturing industry and needs to be taken with caution. The high level of aggregation of available LFS data (1-digit level) masks the true nature of the very heterogeneous manufacturing industry (D), which is made up of a diverse set of industries of different skill intensities that employ HS-TC migrants to different degrees. An analysis of all manufacturing sub-industries would certainly qualify our findings for the overall manufacturing industry and do justice to its diversity. Unfortunately, the high level of aggregation of available LFS data makes a more detailed analysis of the manufacturing industry (D) impossible. Interestingly, a comparison of results for industry D (manufacturing) in Tables B.4 and B.5 shows that all (negative) coefficients of all HS-TC migrant share indicators are higher – sometimes even twice as high – for the ISCO-based measure than the ISCED-based one. This difference suggests that, for the manufacturing industry (D) as a whole, HS-TC migrants – due to the fact that native workers and EU migrants occupy an 'insider' position – tend to be employed in lower level/lower productivity occupations, which reduces labour productivity growth as a whole. A similar negative – but statistically weak – relationship is also found for industry J (finance) but only for the share of HS-TC migrants in total high skilled migrants and only for the ISCED-based skill measure. This seems to suggest that possibly greater cultural differences and language barriers of HS-TC migrants relative to other highly skilled

[9] See Table B.1 for summary statistics of our key variables and Tables B.2a to B.3 for correlation matrices.

migrants (that is: EU HS migrants) hinder the full exploitation of their skills, as measured by their educational attainment level. In contrast, we find a positive – but statistically weak – relationship between real labour productivity growth and the share of HS-TC migrants in the total labour force but only for the ISCO-based skill measure in industry H (hotels and restaurants). Hence, an increased presence of HS-TC migrants who work in high-skill demanding occupations in the overall labour force appears conducive to real labour productivity growth in this industry.

As expected, concerning all other relevant control variables, for the overall sample, both the growth rate of ICT and of non-ICT capital are associated with higher real labour productivity growth, with a stronger effect coming from non-ICT capital growth. We observe a more diversified picture at the industry-level, with particularly strong positive effects of non-ICT capital growth in industries H (hotels and restaurants) and K (real estate and business services).

Results for TFP growth are provided in Table 2 below for the total sample and all relevant industries together (i.e. excluding all public sector industries). Columns (1) to (4) refer to high skills as defined by the ISCED classification while columns (5) to (8) refer to high skills as defined by the ISCO classification. In general, and in contrast to our analysis of real labour productivity growth, the presence of HS-TC migrants matters for TFP growth. More specifically, an increase in the share of HS-TC migrants in the total high-skilled labour force is associated with higher TFP growth. But this only holds for the ISCED-based measure. The size and level of significance of the coefficients suggest that the effect is rather weak and statistically only significant at the 10 per cent level. This positive relationship points to the importance of the composition of the skilled workforce and the importance of HS-TC migrants in the overall HS labour force for TFP growth. However, the absence of any statistically significant coefficients for the ISCO-based measure points to the presence and importance of jobs-skills mismatch. It suggests that HS-TC migrants are more strongly employed in lower level (lower productivity) occupations than other highly skilled workers. This underutilisation of their formal educational attainment levels then leads to no significant contribution for TFP growth.

Again, the strong observable industry heterogeneity warrants a more detailed industry-level analysis to bring out prevailing cross-industry differences. Results for the industries of interest are provided in Tables B.6 (ISCED-based) and B.7 (ISCO-based) in Annex B. In general, industry-level results for the selected industries are diverse and partly in line with above results (see Table 1). In particular, only in industry H (hotels and restaurants) is an increase in the share of HS-TC migrants in the total high-skilled workforce associated with (statistically significant) higher TFP growth. However, this positive relationship only holds for the ISCED-based skill measure – but is absent for the ISCO-based measure – and is therefore reflective of the very pronounced jobs-skills mismatch in this particular industry and the strong underrepresentation of HS-TC migrants in high level occupations (see Panel B in Figure 3). In contrast, for industry D (manufacturing) for both skill measures and industry K (real estate and business services) for the ISCO-based measure only, we find a statistically significant negative relationship between an increase in the share of HS-TC migrants in the migrant workforce and TFP growth. This finding implies that HS-TC migrants in industry D (manufacturing) are more strongly employed in lower level, lower productivity occupations than EU migrant workers, on average. However, as has been mentioned above already, the high level of aggregation of our available data masks the industry's pronounced diversity. For industry K (real estate and business services) the difference in results in terms of skill classifications (ISCED versus ISCO) is again a manifestation of a non-negligible jobs-skills mismatch.

Table 1 / Real labour productivity growth (production function approach including HS-TCNs): 2005-2015, OMS, total sample

	ISCED-based								ISCO-based							
	FE	RE	FE	RE	FE	RE	FE	RE	FE	RE	FE	RE	FE	RE	FE	RE
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)
Δln ICT capital	0.040*	0.051**	0.033*	0.044**	0.039*	0.051**	0.041*	0.055**	0.006	0.016	0.004	0.014	0.008	0.022	0.006	0.010
per hours worked	(1.857)	(2.345)	(1.712)	(2.241)	(1.922)	(2.445)	(1.813)	(2.418)	(0.278)	(0.716)	(0.189)	(0.602)	(0.402)	(0.988)	(0.302)	(0.452)
Δln non-ICT capital	0.263***	0.270***	0.236***	0.243***	0.251***	0.262***	0.195**	0.223***	0.304***	0.296***	0.269***	0.265***	0.321***	0.302***	0.302***	0.267***
per hours worked	(3.278)	(4.451)	(2.708)	(3.679)	(3.191)	(4.304)	(2.190)	(3.129)	(3.648)	(4.648)	(2.993)	(4.024)	(4.194)	(5.176)	(3.106)	(3.426)
Δ share of HS	0.018	0.071	-0.036	0.034	-0.090	-0.048	-0.129	-0.069	-0.014	0.049	0.000	0.032	0.006	0.074	0.023	0.024
in total WF	(0.136)	(0.607)	(-0.291)	(0.298)	(-0.674)	(-0.389)	(-1.060)	(-0.634)	(-0.166)	(0.573)	(0.004)	(0.356)	(0.071)	(0.921)	(0.313)	(0.320)
Δ share of HS-TCN	-0.148	-0.157							-0.380	-0.205						
in total WF	(-0.318)	(-0.350)							(-0.858)	(-0.502)						
Δ share of HS-TCN			0.069	0.057							0.001	0.064				
in HS WF			(0.739)	(0.610)							(0.007)	(0.479)				
Δ share of HS-TCN					0.035	0.020							-0.019	0.006		
in migrant WF					(0.590)	(0.345)							(-0.363)	(0.131)		
Δ share of HS-TCN							-0.012	-0.008							-0.006	0.003
in HS migrant WF							(-0.578)	(-0.402)							(-0.257)	(0.157)
Country FE	yes	Yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Industry FE	yes	Yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Year FE	yes	Yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Constant	1.485**	1.476**	1.347**	1.192*	1.242**	1.155*	1.083*	0.847	1.505***	1.568**	1.492**	1.667**	1.485***	1.571**	1.304**	1.406**
	(2.480)	(2.273)	(2.202)	(1.776)	(2.223)	(1.809)	(1.785)	(1.223)	(2.705)	(2.542)	(2.541)	(2.575)	(2.680)	(2.537)	(2.368)	(2.304)
Observations	802	802	798	798	795	795	780	780	778	778	764	764	787	787	747	747
Adjusted R^2	0.149		0.139		0.148		0.156		0.152		0.136		0.154		0.174	

Robust t-statistics in parentheses; *** p<0.01, ** p<0.05, * p<0.1

Table 2 / TFP growth: 2005-2015, OMS, total sample

	ISCED-based				ISCO-based			
	FE	FE	RE	RE	FE	FE	RE	RE
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Δ share of migrants in total WF	0.081	0.143	-0.026	0.025	-0.069	0.011	-0.151	-0.109
	(0.580)	(1.065)	(-0.186)	(0.190)	(-0.570)	(0.097)	(-1.176)	(-0.945)
Δ share of HS-TCN in HS WF	0.169*		0.149*		-0.061		0.003	
	(1.781)		(1.701)		(-0.430)		(0.025)	
Δ share of HS-TCN in migrant WF		0.023		0.006		-0.032		-0.020
		(0.357)		(0.084)		(-0.858)		(-0.509)
Country FE	yes	yes	yes	yes	yes	yes	yes	yes
Industry FE	yes	yes	yes	yes	yes	yes	yes	yes
Year FE	yes	yes	yes	yes	yes	yes	yes	yes
Constant	1.218***	1.206**	1.153***	1.151***	1.169**	1.160***	1.160***	1.126***
	(2.638)	(2.591)	(2.634)	(2.632)	(2.475)	(2.682)	(2.585)	(2.644)
Observations	832	823	832	823	801	817	801	817
Adjusted R^2	0.143	0.150			0.154	0.148		

Robust t-statistics in parentheses; *** p<0.01, ** p<0.05, * p<0.1.

6. Addressing endogeneity

To address the potential reverse causality/endogeneity issue of HS-TC migration, we also estimated interval regressions. However, due to the significant reduction in the number of observations as a result of the reduction of the time dimension to three periods only, a separate analysis by individual industries was impossible. Results for real labour productivity growth for the total EU-13 sample are reported in Table 3 below, where columns (1) to (8) again refer to high skills as defined by the ISCED classification while columns (9) to (16) again refer to high skills as defined by the ISCO classification. In general, our results confirm above findings (see Table 1) of a statistically insignificant role of HS-TC migration for real labour productivity growth, with only three exceptions. First, we find that an increase in the share of HS-TC migrants in the total workforce results in lower average real labour productivity growth (particularly for the ISCED-based measure). Second, an increase in the share of HS-TC migrants in the HS workforce also leads to lower average real labour productivity growth, which, however, only holds for the ISCO-based measure (and the FE model only). The presence of a non-negligible jobs-skills mismatch helps explain this finding, with HS-TC migrants more strongly occupying lower level (lower productivity) occupations than other HS (native and foreign) workers, on average. Third, there is also weak evidence (at the 10% level only) that an increase in the share of HS-TC migrants in the total HS migrant workforce results in lower average real labour productivity growth. However, this only holds for the ISCED-based skills measure (and the FE model only), which suggests that possibly greater cultural differences and language barriers of HS-TC migrants (relative to other highly skilled EU HS migrants) hinder the full exploitation of their skills, as measured by their educational attainment level. This makes HS-TC migrants less productive than HS EU migrants with similarly high educational attainment levels.

Furthermore, Table 4 below reports results for TFP growth, where columns (1) to (4) again refer to high skills as defined by the ISCED classification while columns (5) and (8) refer to high skills as defined by the ISCO classification. Table 4 reveals that once endogeneity is accounted for, our results show that an increase in the share of HS-TC migrants – either as a share in the HS workforce or the HS migrant workforce – has no statistically significant effect on TFP growth, irrespective of classification considered. Instead, our results emphasise that an increase in the share of migrants in general (in the total workforce) matters for TFP growth, particularly for the RE model.[10] Specifically, an increase in the share of migrants in the total workforce leads to lower average TFP growth, irrespective of skills measure used.

[10] The absence of any statistically significant effect for the FE models suggests that migrants predominantly work in lower productivity industries.

Table 3 / Real labour productivity growth: interval regressions, OMS, total sample

	ISCED-based								ISCO-based							
	FE	RE	FE	RE	FE	RE	FE	RE	FE	RE	FE	RE	FE	RE	FE	RE
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)
ΔIn ICT capital	0.025	0.066**	0.044	0.078***	0.058*	0.082***	0.027	0.069**	0.046	0.085**	0.037	0.059**	0.038	0.084**	0.032	0.080**
per hours worked	(0.813)	(2.316)	(1.164)	(2.734)	(1.671)	(2.794)	(0.670)	(2.362)	(1.362)	(2.485)	(1.125)	(2.134)	(1.111)	(2.493)	(0.995)	(2.212)
ΔIn non-ICT capital	0.117	0.112	0.177	0.161**	0.160	0.158*	0.094	0.116	0.172	0.206***	0.106	0.214***	0.108	0.164**	0.157	0.183**
per hours worked	(0.950)	(1.400)	(1.437)	(1.979)	(1.320)	(1.921)	(0.724)	(1.300)	(1.242)	(2.709)	(0.819)	(3.179)	(0.844)	(2.305)	(1.226)	(2.232)
Δ share of HS	0.109	0.166	0.081	0.092	0.109	0.059	0.051	0.098	-0.015	-0.053	-0.046	-0.100	-0.012	-0.078	-0.014	-0.088
in total WF	(0.780)	(1.557)	(0.627)	(0.955)	(0.814)	(0.532)	(0.382)	(0.993)	(-0.149)	(-0.615)	(-0.484)	(-1.093)	(-0.132)	(-0.896)	(-0.162)	(-1.077)
Δ share of HS-TCN	-1.025**	-0.961**							-0.839*	-0.345						
in total WF	(-2.203)	(-2.371)							(-1.892)	(-0.887)						
Δ share of HS-TCN			-0.073	-0.088							-0.330**	-0.123				
in HS WF			(-0.820)	(-1.072)							(-2.404)	(-1.081)				
Δ share of HS-TCN					-0.024	0.033							-0.003	0.023		
in migrant WF					(-0.468)	(0.579)							(-0.050)	(0.433)		
Δ share of HS-TCN							-0.048*	-0.028							0.018	0.001
in HS migrant WF							(-1.950)	(-1.287)							(0.576)	(0.048)
Country FE	yes	yes	yes	Yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Industry FE	yes	yes	yes	Yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Period FE	yes	yes	yes	Yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Constant	1.020***	0.814**	0.767**	0.680**	0.697**	0.646*	0.907***	0.701**	0.967***	0.758**	0.967***	0.858**	0.845***	0.739**	0.947***	0.821**
	(3.344)	(2.304)	(2.512)	(1.981)	(2.392)	(1.860)	(2.967)	(2.096)	(3.340)	(2.091)	(3.426)	(2.463)	(2.926)	(2.087)	(3.267)	(2.260)
Observations	253	253	256	256	255	255	255	255	243	243	246	246	249	249	242	242
Adjusted R^2	0.07		0.058		0.069		0.068		0.076		0.07		0.046		0.063	

Robust t-statistics in parentheses; *** p<0.01, ** p<0.05, * p<0.1.
Note: Period FEs refer to the three periods over which interval regressions were estimated (1: 2005-2007, 2: 2008-2011 and 3: 2012-2015).

Table 4 / TFP growth: interval regressions, OMS, total sample

	ISCED-based				ISCO-based			
	FE	FE	RE	RE	FE	FE	RE	RE
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Δ share of migrants in total WF	-0.193*	-0.165	-0.331***	-0.365***	-0.158	-0.098	-0.314**	-0.291**
	(-1.910)	(-1.589)	(-3.520)	(-3.253)	(-1.104)	(-0.812)	(-2.390)	(-2.355)
Δ share of HS-TCN in HS WF	0.070		-0.085		-0.099		0.007	
	(0.782)		(-0.782)		(-0.559)		(0.045)	
Δ share of HS-TCN in migrant WF		0.055		0.016		-0.038		-0.024
		(0.987)		(0.253)		(-0.552)		(-0.417)
Country FE	yes	yes	yes	yes	yes	yes	yes	yes
Industry FE	yes	yes	yes	yes	yes	yes	yes	yes
Period FE	yes	yes	yes	yes	yes	yes	yes	yes
Constant	1.385***	1.317***	1.727***	1.641***	1.330***	1.214***	1.625***	1.575***
	(5.739)	(5.384)	(5.550)	(5.064)	(5.295)	(4.920)	(4.897)	(4.815)
Observations	256	257	256	257	246	248	246	248
Adjusted R^2	0.155	0.157			0.149	0.150		

Robust t-statistics in parentheses; *** p<0.01, ** p<0.05, * p<0.1.
Note: Period FEs refer to the three periods over which interval regressions were estimated (1: 2005-2007, 2: 2008-2011 and 3: 2012-2015).

7. Conclusion

In view of its importance for innovation and economic performance, skilled migration has received considerable academic and policy attention. In the context of the European Innovation Union (IU), skilled migration and the need for integrated policies to attract high-skilled third-country (HS-TC) nationals, in general, and leading academics, researchers and innovators, in particular, received specific attention by policy-makers in order to boost the EU's innovative capacity and competitiveness.

In our analysis, we looked at the group of HS-TC migrants to shed light on their role for innovation – as proxied by labour productivity and TFP – and thus for productivity improvements in the private company sector. We used EU-LFS and EU-KLEMS data at the 1-digit level (NACE Rev. 1.1) for a group of 13 old EU Member States (EU-13) and looked at four different indicators of HS-TC migration for two different classifications (ISCED and ISCO) for the period 2004 to 2015. The distinction between ISCED and ISCO-based measures allowed us to identify the presence and effects of jobs-skills mismatch of HS-TC migrants on innovation.

We show that, except for the UK, countries with colonial connections and with a high share of migrants or of refugees, HS-TC migrants only make up a low share of the total workforce in the EU-13. Furthermore, the importance of HS-TC migrants differs across industries and, when measured as a share in the total workforce, is highest in industries C (mining)[11], J (finance), K (real estate and business services) and public services industries such as M (education) and N (health and social work).

Moreover, the extent of a skills-jobs mismatch is sizeable for HS-TC migrants. At the individual country-level, skills-jobs mismatch is observable for all EU-13 countries, but is particularly pronounced in Sweden, Austria, Spain and the UK. At the level of individual industries, skills-jobs mismatch is also prevalent in all industries but is particularly strong in industry H (hotels and restaurants).

Furthermore, our econometric analysis produces somewhat mixed results as concerns the role of HS-TC migrants for real labour productivity and TFP growth, which is partly driven by missing data (in the EU-KLEMS) on TFP growth for the two important host countries of HS-TC migrants Ireland and Portugal. On the one hand, for the overall sample, we find consistent evidence that the share of HS-TC migrants (in different workforce populations) is statistically unrelated to real labour productivity growth. However, for individual industries separately, some negative (such as for industry D (manufacturing) and J (finance)) but also positive (such as for industry H (hotels and restaurants)) relationships emerge. Differences in results across skills measures (ISCED versus ISCO) suggest that a non-negligible jobs-skills mismatch but also greater cultural differences and language barriers of HS-TC migrants are at play. On the other hand, our results show that an increase in the share of HS-TC migrants in the HS workforce is associated with consistently higher TFP growth, but only for the ISCED-based classification. This finding is reflective of the important role played by HS-TC migrants among HS workers as a whole but also points to the presence of a jobs-skills mismatch. The picture is again more diverse for individual industries. Only industry H (hotels and restaurants) seems to profit from an increase in the share of HS-

[11] This is due to a high share of HS-TC employees in the North Sea oil and gas industry.

TC migrants (in the total HS workforce) in terms of higher TFP growth. This positive effect, however, only holds for the ISCED-based skill measure but is absent for the ISCO-based skill measure which points to the rather pronounced jobs-skills mismatch in this industry and the strong underrepresentation of HS-TC migrants in high level, high productivity occupations. In contrast, in industries D (manufacturing) and K (real estate and business services) we observe a negative relationship between an increase in the share of HS-TC migrants (in the migrant workforce) and TFP growth. For industry D (manufacturing) this negative relationship is observable for both skill measures (ISCED and ISCO). In contrast, for industry K (real estate and business services) this negative relationship is only observable for the ISCO-based skills measure which suggests that, contrary to what their educational attainment levels would warrant, HS-TC migrants are more strongly employed in lower level, lower productivity occupations.

Once potential endogeneity of HS-TC migration is accounted for and causation is more clearly established, negative effects of a higher share of HS-TC prevail: an increase in the share of HS-TC migrants (either as a share in the total workforce, in the high skilled workforce or in the high skilled migrant workforce) has a partial negative effect on real labour productivity growth. Similarly, an increase in the share of HS-TC migrants (in the total workforce) leads to lower average TFP growth.

Unfortunately, our analysis is restricted by data limitations as a result of the high level of aggregation of EU-LFS data at the 1-digit level. This makes it impossible to conduct a thorough analysis at the more detailed industry level, account for prevailing industry heterogeneity, and bring to the fore important differences across sub-industries. This limitation is particularly strong for industry D (manufacturing), which is composed of a large set of diverse industries and explains the difference in more positive results obtained in the studies by Huber et al. (2010) and Fassio et al. (2015) with regard to the positive impact of (high-skilled) migrants in (high-skilled) industries, determined by a higher share of skilled workers.

From a policy-perspective, our analysis implies the following: First, the non-negligible jobs-skills mismatch for HS-TC migrants found in our analysis – in terms of their over-representation in lower productivity occupations – is indicative of brain waste. Hence, policies are called for which help reduce this mismatch to guarantee that HS-TC migration can have its full innovation- and growth-enhancing effects, as envisaged by many policy-makers. Second, the lower productivity of HS-TC migrants as compared to HS EU migrants, which results from stronger cultural differences and language barriers of HS-TC migrants, requires specific policies that are tailored to and address the particular needs and deficiencies of HS-TC migrants.

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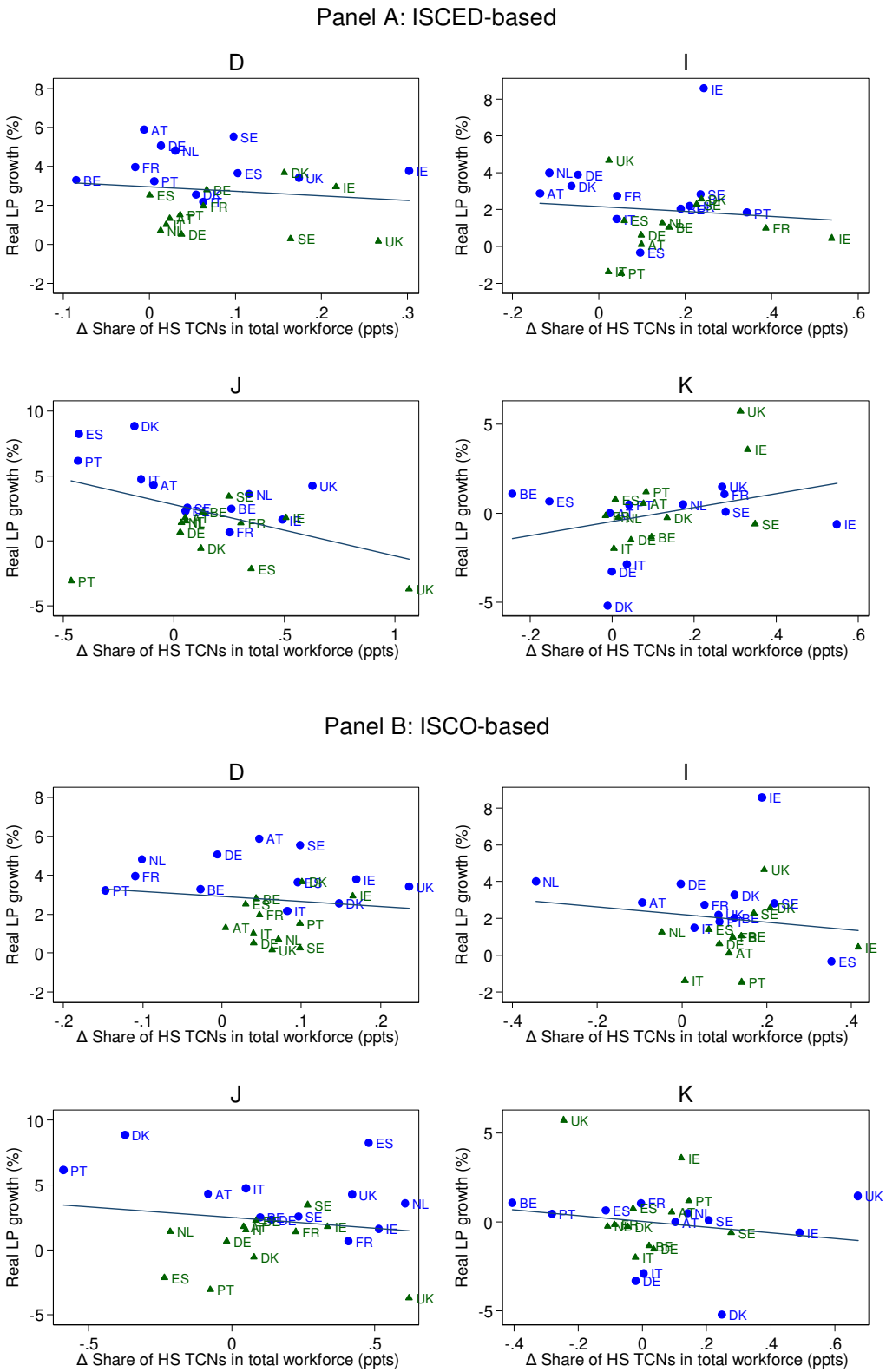
9. Annex A

Table A.1 / NACE Rev. 1.1 classification

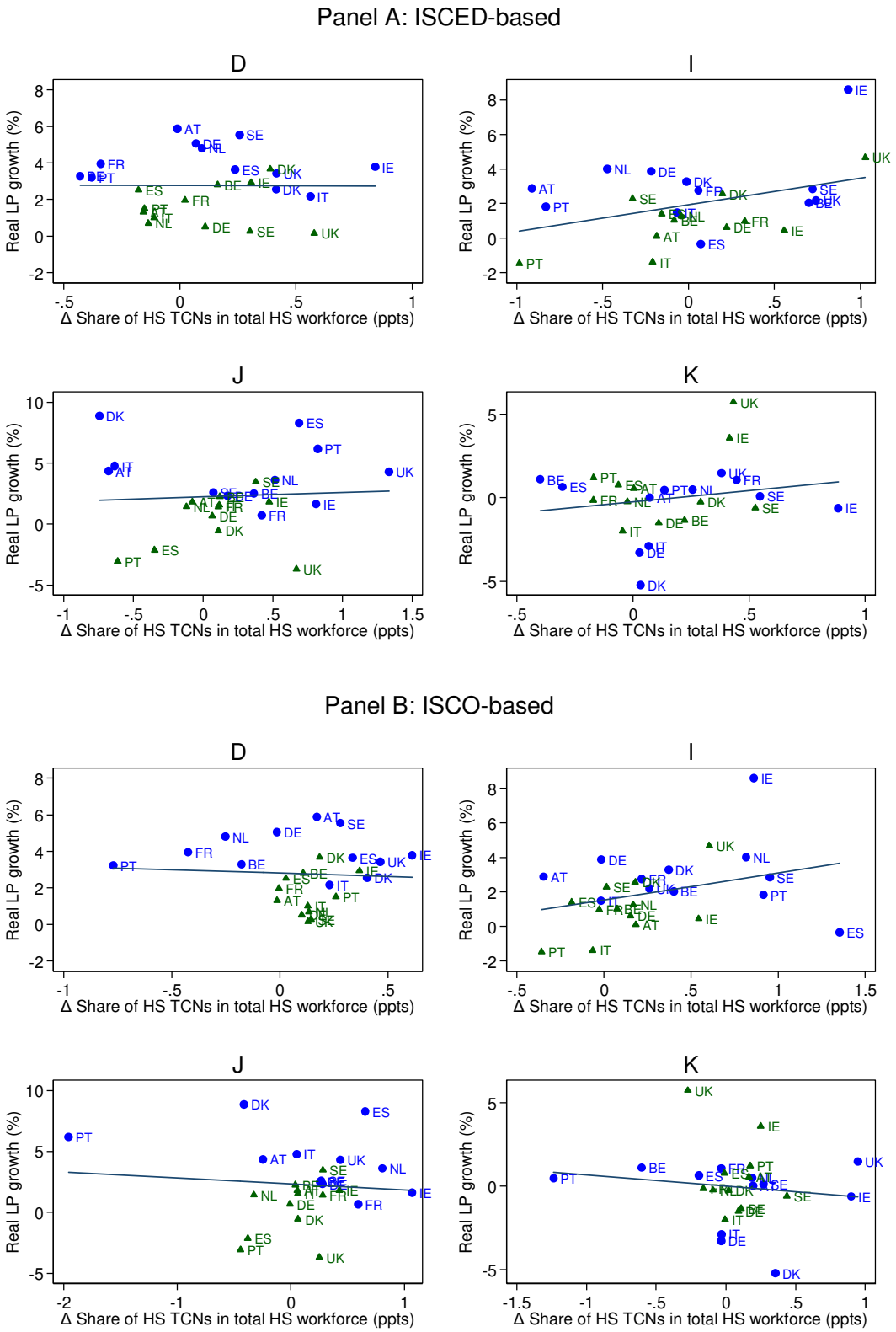
Section	Description
A	Agriculture, hunting and forestry
B	Fishing
C	Mining and quarrying
D	Manufacturing
E	Electricity, gas and water supply
F	Construction
G	Wholesale and retail trade: repair of motor vehicles, motorcycles and personal and household goods
H	Hotels and restaurants
I	Transport, storage and communications
J	Financial intermediation
K	Real estate, renting and business activities
L	Public administration and defence; compulsory social security
M	Education
N	Health and social work
O	Other community, social and personal services activities
P	Activities of private households as employers and undifferentiated production activities of private households
Q	Extraterritorial organisations and bodies

Figure A.1 / Relationship between the real labour productivity growth and the change in the share of HS-TCNs in the total workforce



Note: 2005-07: solid circles; 2008-15: solid triangles.
Source: EU LFS, own calculations.

Figure A.2 / Relationship between the real labour productivity growth rate and the change in the share of HS-TCNs in the total HS workforce



Note: 2005-07: solid circles; 2008-15: solid triangles.
Source: EU LFS, own calculations.

10. Annex B

Table B.1 / Summary statistics

Variable	Abbrev.	Obs	Mean	Std. Dev.	Min	Max
GR real labour productivity per hour worked	GR RLPh	1,219	0.52	5.04	-14.14	14.67
GR Total Factor Productivity	GR TFP	1,069	-0.11	5.67	-26.29	21.82
GR ICT capital per hour worked	GR ITCAPh	1,071	4.02	9.17	-95.31	69.32
GR non-ICT capital per hour worked	GR NITCAPh	1,070	1.11	4.55	-15.88	27.16
Δ share of HS in total workforce (ISCED)	ΔshHS	1,055	0.93	1.76	-4.95	7.16
Δ share of HS-TCN in total workforce (ISCED)	ΔshHSTCNtot	1,056	0.10	0.48	-1.57	1.84
Δ share of HS-TCN in HS WF (ISCED)	ΔHSTCNhs	1,055	0.11	2.10	-7.13	7.43
Δ share of HS-TCN in migrant WF (ISCED)	ΔshHSTCNmig	1,048	0.43	3.23	-10.67	11.83
Δ share of HS-TCN in HS migrant WF (ISCED)	ΔshHSTCNhsmig	1,037	-0.37	9.32	-28.45	27.37
Δ share of migrants in total workforce (ISCED)	ΔshMIG	1,038	0.53	1.42	-3.97	5.19
Δ share of HS in total workforce (ISCO)	ΔshHS	1,019	0.20	2.23	-7.66	9.29
Δ share of HS-TCN in total workforce (ISCO)	ΔshHSTCNtot	1,023	0.05	0.46	-1.61	1.76
Δ share of HS-TCN in HS WF (ISCO)	ΔshHSTCNhs	1,007	0.11	1.29	-4.36	4.64
Δ share of HS-TCN in migrant WF (ISCO)	ΔshHSTCNmig	1,036	-0.03	3.56	-13.64	12.62
Δ share of HS-TCN in HS migrant WF (ISCO)	ΔshHSTCNhsmig	998	0.05	8.47	-26.62	26.58
Δ share of migrants in total workforce (ISCO)	ΔshMIG	1,019	0.48	1.42	-3.92	5.01

Source: EU-KLEMS and EU-LFS, own calculations.

Table B.2a / Correlation matrices – labour productivity specification: ISCED-based

	GR ITCAPh	GR NITCAPh	ΔshHS	ΔshHSTCNtot	ΔHSTCNhs	ΔshHSTCNmig	ΔshHSTCNhsmig
GR ITCAPh	1						
GR NITCAPh	0.30	1					
	(0.00)						
ΔshHS	0.03	0.11	1				
	(0.44)	(0.00)					
ΔshHSTCNtot	-0.01	0.01	0.28	1			
	(0.72)	(0.72)	(0.00)				
ΔHSTCNhs	-0.02	0.02	0.03	0.76	1		
	(0.62)	(0.59)	(0.27)	(0.00)			
ΔshHSTCNmig	0.01	0.05	0.28	0.77	0.64	1	
	(0.72)	(0.15)	(0.00)	(0.00)	(0.00)		
ΔshHSTCNhsmig	-0.05	0.03	0.04	0.45	0.56	0.55	1
	(0.17)	(0.40)	(0.19)	(0.00)	(0.00)	(0.00)	

Source: EU-KLEMS and EU-LFS, own calculations.

Table B.2b / Correlation matrices – labour productivity specification: ISCO-based

	GR ITCAPh	GR NITCAPh	ΔshHS	ΔshHSTCNtot	ΔHSTCNhs	ΔshHSTCNmig	ΔshHSTCNhsmig
GR ITCAPh	1						
GR NITCAPh	0.30	1					
	(0.00)						
ΔshHS	-0.02	0.05	1				
	(0.5)	(0.13)					
ΔshHSTCNtot	-0.05	0.03	0.17	1			
	(0.13)	(0.44)	(0.00)				
ΔHSTCNhs	0.00	0.04	-0.03	0.79	1		
	(0.91)	(0.21)	(0.32)	(0.00)			
ΔshHSTCNmig	0.02	0.06	0.17	0.73	0.61	1	
	(0.63)	(0.08)	(0.00)	(0.00)	(0.00)		
ΔshHSTCNhsmig	-0.01	-0.05	-0.06	0.47	0.52	0.53	1
	(0.76)	(0.19)	(0.05)	(0.00)	(0.00)	(0.00)	

Source: EU-KLEMS and EU-LFS, own calculations.

Table B.3 / Correlation matrices – TFP specification: ISCED-based (Panel A) and ISCO-based (Panel B)

Panel A: ISCED-based

	ΔshMIG	ΔHSTCNhs	ΔshHSTCNmig
ΔshMIG	1		
ΔHSTCNhs	0.29	1	
	(0.00)		
ΔshHSTCNmig	-0.01	0.64	1
	(0.82)	(0.00)	

Source: EU-KLEMS and EU-LFS, own calculations.

Panel B: ISCO-based

	ΔshMIG	ΔHSTCNhs	ΔshHSTCNmig
ΔshMIG	1		
ΔHSTCNhs	0.33	1	
	(0.00)		
ΔshHSTCNmig	0.01	0.61	1
	(0.75)	(0.00)	

Source: EU-KLEMS and EU-LFS, own calculations.

Table B.4 / Real labour productivity growth (production function approach including HS-TCNs): 2005-2015, OMS, selected industries, ISCED-based

	D	D	D	D	H	H	H	H	I	I	I	I	J	J	J	J	K	K	K	K
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)
ΔIn ICT capital per hour worked	0.037	0.046	0.038	0.044	-0.010	-0.043	-0.025	-0.007	-0.041	-0.021	-0.044	-0.034	0.005	0.009	0.023	-0.002	-0.170*	-0.170*	-0.178*	-0.173*
	(0.446)	(0.556)	(0.448)	(0.528)	(-0.144)	(-0.512)	(-0.353)	(-0.097)	(-0.413)	(-0.228)	(-0.441)	(-0.354)	(0.098)	(0.182)	(0.328)	(-0.025)	(-1.865)	(-1.865)	(-1.930)	(-1.918)
ΔIn non-ICT capital per hour worked	0.094	0.092	0.094	0.069	0.568***	0.599***	0.664***	0.603***	-0.011	-0.006	-0.006	0.007	-0.116	-0.176	-0.171	-0.234	0.462***	0.460***	0.457***	0.479***
	(0.454)	(0.459)	(0.456)	(0.346)	(3.726)	(3.186)	(4.205)	(3.628)	(-0.088)	(-0.044)	(-0.042)	(0.053)	(-0.690)	(-1.119)	(-0.812)	(-1.457)	(3.459)	(3.524)	(3.467)	(3.758)
Δ share of HS in total WF	0.386	0.276	0.363	0.232	0.052	0.112	0.198	-0.048	0.067	-0.051	0.069	-0.093	0.120	0.022	-0.010	0.040	-0.327	-0.322	-0.298	-0.367*
	(0.979)	(0.737)	(0.913)	(0.584)	(0.140)	(0.381)	(0.592)	(-0.168)	(0.306)	(-0.263)	(0.312)	(-0.451)	(0.493)	(0.096)	(-0.039)	(0.174)	(-1.481)	(-1.600)	(-1.246)	(-1.800)
Δ share of HS-TCN in total WF	-2.404*				0.400				-0.772				-1.307				0.030			
	(-1.843)				(0.504)				(-0.735)				(-1.092)				(0.028)			
Δ share of HS-TCN in HS WF		-0.499				0.158				-0.385				-0.555				-0.010		
		(-1.533)				(1.161)				(-1.528)				(-1.066)				(-0.021)		
Δ share of HS-TCN in migrant WF			-0.293*				-0.195				-0.062				-0.057				0.023	
			(-1.908)				(-1.331)				(-0.563)				(-0.373)				(0.127)	
Δ share of HS-TCN in HS migrant WF				-0.100**				0.028				-0.027				-0.113*				0.064
				(-2.123)				(0.640)				(-0.631)				(-1.966)				(1.090)
Country FE	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Year FE	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Constant	4.132***	3.958***	3.993***	-5.955**	1.317	-4.087	-5.098**	1.660	1.207	1.575	1.114	1.906	-0.464	-0.600	0.284	-0.339	-0.770	0.906	-0.751	0.959
	(3.467)	(3.307)	(3.431)	(-1.998)	(0.816)	(-1.483)	(-2.541)	(1.049)	(0.925)	(1.190)	(0.865)	(1.238)	(-0.193)	(-0.253)	(0.160)	(-0.127)	(-0.416)	(0.745)	(-0.404)	(0.801)
Observations	104	104	104	104	101	89	104	99	96	97	96	97	100	104	89	99	103	103	101	103
Adjusted R^2	0.485	0.477	0.481	0.484	0.219	0.191	0.232	0.217	0.262	0.258	0.259	0.237	0.068	0.068	0.025	0.097	0.225	0.225	0.220	0.234

Robust t-statistics in parentheses; *** p<0.01, ** p<0.05, * p<0.1.

Table B.5 / Real labour productivity growth (production function approach including HS-TCNs): 2005-2015, OMS, selected industries, ISCO-based

	D	D	D	D	H	H	H	H	I	I	I	I	J	J	J	J	K	K	K	K
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)
ΔIn ICT capital per hour worked	0.041	0.033	0.053	0.042	-0.000	-0.009	-0.022	-0.026	-0.052	-0.057	-0.052	-0.052	0.017	0.016	0.045	0.029	-0.155	-0.155	-0.154	-0.158
	(0.499)	(0.399)	(0.638)	(0.509)	(-0.003)	(-0.112)	(-0.316)	(-0.384)	(-0.555)	(-0.597)	(-0.538)	(-0.539)	(0.317)	(0.301)	(0.849)	(0.504)	(-1.597)	(-1.597)	(-1.546)	(-1.618)
ΔIn non-ICT capital per hour worked	0.117	0.109	0.103	0.033	0.566***	0.496***	0.576***	0.599***	-0.018	-0.017	-0.004	-0.001	-0.147	-0.192	-0.164	-0.177	0.384***	0.383***	0.387***	0.388***
	(0.574)	(0.539)	(0.516)	(0.173)	(4.343)	(3.070)	(3.858)	(3.974)	(-0.139)	(-0.126)	(-0.029)	(-0.008)	(-0.906)	(-1.264)	(-0.963)	(-1.147)	(3.232)	(3.212)	(3.259)	(3.197)
Δ share of HS in total WF	-0.157	-0.247	-0.156	-0.174	-0.090	0.165	-0.121	0.074	-0.118	-0.168	-0.144	-0.141	0.014	-0.010	0.048	-0.044	-0.101	-0.116	-0.105	-0.119
	(-0.547)	(-0.878)	(-0.548)	(-0.649)	(-0.459)	(0.597)	(-0.584)	(0.349)	(-0.706)	(-1.074)	(-0.779)	(-0.858)	(0.078)	(-0.054)	(0.280)	(-0.235)	(-0.619)	(-0.687)	(-0.637)	(-0.698)
Δ share of HS-TCN in total WF	-2.883***				1.187*				-1.079				-1.423				-0.435			
	(-2.926)				(1.750)				(-1.176)				(-1.214)				(-0.319)			
Δ share of HS-TCN in HS WF		-1.115***				0.068				-0.399				-0.192				-0.251		
		(-3.139)				(0.301)				(-1.053)				(-0.280)				(-0.331)		
Δ share of HS-TCN in migrant WF			-0.417***				0.216				-0.044				-0.054				-0.060	
			(-3.719)				(1.293)				(-0.386)				(-0.508)				(-0.306)	
Δ share of HS-TCN in HS migrant WF				-0.207***				0.032				-0.039				-0.066				-0.010
				(-4.583)				(0.905)				(-0.940)				(-1.002)				(-0.122)
Country FE	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Year FE	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Constant	4.492***	4.506***	4.549***	4.136***	0.153	4.595***	1.453	4.325***	1.340	1.293	1.216	1.150	4.143**	3.750**	2.837*	4.274**	0.566	0.569	-0.798	-0.784
	(3.656)	(3.704)	(3.792)	(3.431)	(0.116)	(3.106)	(0.911)	(3.405)	(1.022)	(0.983)	(0.926)	(0.896)	(2.231)	(2.061)	(1.672)	(2.095)	(0.481)	(0.482)	(-0.458)	(-0.446)
Observations	105	105	105	105	96	80	101	100	96	95	96	96	103	105	99	102	104	104	104	104
Adjusted R^2	0.492	0.498	0.503	0.542	0.302	0.228	0.246	0.236	0.266	0.258	0.250	0.257	0.069	0.065	0.038	0.052	0.222	0.222	0.221	0.219

Robust t-statistics in parentheses; *** p<0.01, ** p<0.05, * p<0.1.

Table B.6 / TFP growth: 2005-2015, OMS, selected industries, ISCED-based

	D	D	H	H	I	I	J	J	K	K
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Δ share of migrants in total WF	-0.351	-0.442	0.210	0.099	-0.091	-0.164	0.507	0.081	0.036	0.001
	(-1.137)	(-1.565)	(1.121)	(0.597)	(-0.416)	(-0.692)	(1.012)	(0.154)	(0.151)	(0.004)
Δ share of HS-TCN in HS WF	-0.264		0.147**		0.048		-0.635		0.001	
	(-0.860)		(2.102)		(0.381)		(-1.369)		(0.006)	
Δ share of HS-TCN in migrant WF		-0.298**		-0.129		-0.114		-0.058		0.038
		(-2.064)		(-0.914)		(-1.294)		(-0.446)		(0.454)
Country FE	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Year FE	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Constant	1.941*	2.075*	-1.134	0.461	0.285	0.403	2.198	2.477	-2.271**	0.039
	(1.782)	(1.911)	(-0.906)	(0.459)	(0.444)	(0.602)	(1.146)	(1.472)	(-2.249)	(0.038)
Observations	107	107	86	100	107	103	106	91	106	104
Adjusted R^2	0.594	0.608	0.230	0.170	0.367	0.376	0.058	0.026	0.352	0.372

Robust t-statistics in parentheses; *** p<0.01, ** p<0.05, * p<0.1.

Table B.7 / TFP growth: 2005-2015, OMS, selected industries, ISCO-based

	D	D	H	H	I	I	J	J	K	K
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Δ share of migrants in total WF	-0.227	-0.412	0.134	-0.005	-0.026	-0.045	0.116	0.038	0.148	0.004
	(-0.743)	(-1.523)	(0.559)	(-0.031)	(-0.117)	(-0.220)	(0.228)	(0.074)	(0.613)	(0.017)
Δ share of HS-TCN in HS WF	-0.767**		-0.008		0.075		-0.459		-0.480	
	(-2.032)		(-0.044)		(0.321)		(-0.700)		(-1.552)	
Δ share of HS-TCN in migrant WF		-0.336***		-0.056		-0.057		-0.057		-0.184**
		(-2.688)		(-0.607)		(-0.636)		(-0.661)		(-2.392)
Country FE	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Year FE	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Constant	2.061*	2.045*	-0.450	2.467**	1.428**	0.282	0.565	2.642	1.251*	1.332*
	(1.855)	(1.822)	(-0.345)	(2.074)	(2.097)	(0.416)	(0.352)	(1.618)	(1.757)	(1.850)
Observations	107	107	80	102	106	105	107	101	106	106
Adjusted R^2	0.603	0.614	0.223	0.183	0.359	0.370	0.047	0.07	0.368	0.393

Robust t-statistics in parentheses; *** p<0.01, ** p<0.05, * p<0

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