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Abstract

Since 2014 Poland witnessed an unprecedented inflow of immigrant workers from Ukraine. Coupled with strong labour demand, this surge in labour supply provided a major contribution to Poland's economic growth. However, due to problems with capturing immigration in Labour Force Survey (LFS) data this contribution has remained hitherto largely unaccounted in official data. In this paper we use a range of alternative official data sources to estimate the actual number of immigrants, and survey data on migrant characteristics, collected in four Polish cities, to estimate the effective labour supply of Ukrainian immigrants in terms of productivity-adjusted hours worked. We find that the arrival of Ukrainian workers was increasing the effective labour supply in Poland in 2013-18 by 0.8% per annum. Imputing this additional labour supply in a growth accounting exercise we find that the (previously unaccounted) contribution of Ukrainian workers amounted to about 0.5 pp. per annum, i.e., about 13% of Poland's GDP growth in 2013-18. The same figure should be subtracted from the residual contribution of total factor productivity (TFP) growth, suggesting that recent growth in Poland has been in fact much more labour-intensive than previously interpreted.

Keywords: growth accounting, immigration, labour input, Poland, Ukraine

JEL codes: E24, O47, F22, O15.

1 Introduction

Poland is a converging country. Its catch-up process with Western Europe began around 1992 following the preceding turbulent transition period, and over the next decades it was fueled by rapid capital accumulation, systematic improvements in educational attainment of the Polish population as well as technology transfer and institutional convergence in the run-up and after Poland's accession to the European Union in 2004. Despite great improvements, though, until 2013 Poland remained an emigration country. About 1.2 million Poles (3% of the population) left the country between 2002 and 2013, with a particularly remarkable wave of 0.7 million emigrants to the United Kingdom and Ireland in 2004-08.[1]

This situation reversed abruptly in 2014. From that year onward Poland admitted probably between one and two million immigrants from Ukraine (Figure 1).[2] This wave of immigration, of an unprecedented scale in Poland's modern history, was significant also from the European perspective. In particular "in 2018, one out of five first residence permits was issued in Poland (635 000, or 20% of total permits issued in the EU)", and conversely "citizens of Ukraine (527 000 beneficiaries, of which almost 78% in Poland) continued to receive the highest number of permits in the EU" (Eurostat, 2019). A vast majority of Ukrainian immigrants arrived in Poland for economic reasons, and they immediately sought (and most of them found) employment here. Their immigration was prompted inter alia by strong labour demand, relatively easy short-term work and residence permits (pull factors) as well as the Russian aggression on Ukraine in 2014 with an ensuing economic crisis there (push factors). In contrast to migrants from Ukraine to Poland before 2014 – less than 0.2 million of mostly temporary workers in the agricultural sector – the new immigrants located predominantly in cities and sought work across a broad spectrum of economic sectors.

Unfortunately, this massive inflow of Ukrainian workers was only marginally

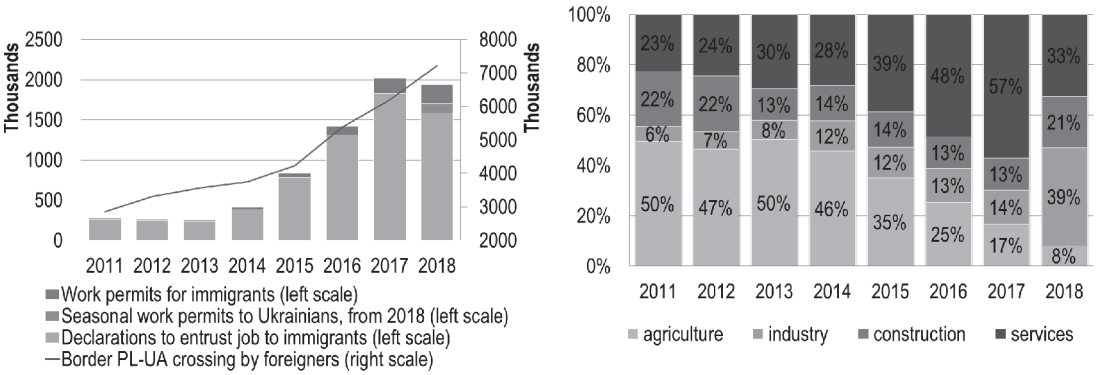
[1] Emigration before 2002 was also substantial but the estimates are not provided by Statistics Poland. Furthermore, negative net migration of Polish citizens – though not as large – has been observed also after 2013.

[2] Immigration from other countries was of lesser importance and did not record such a dramatic surge. According to Polish Social Security Institution (ZUS) data, citizens of all other countries excluding Ukraine constituted in 2019Q3 about one fourth of foreign contribution payers. While the number of Ukrainians paying their social contributions to the Polish social security system was increasing at an average pace of 33% y/y in 2014 and about 92% y/y in the years 2015-2016, the number of contributors from other countries accelerated only after 2016H2. A particularly strong increase was observed in 2018H1 in the case of Georgian immigrants whose number – according to ZUS data – more than tripled, reaching however still a rather minor share of 1.5% of the total.

Figure 1: The scale and sector structure of immigration in Poland

(a) number of immigrants - different sources

(b) sector structure



Source: Ministry of Labour, Polish Border Guard data.

Notes: (1) The left panel refers strictly to Ukrainians, the right to all foreign citizenships, (2)There is a break in data on the sector structure of immigrants since January 2018, when an amendment to the Act on Employment Promotion and Labour Market Institutions came into force, changing the immigration law in Poland in two ways. First, declarations of employers planning to hire foreigners ceased to be only declarations of intention and became declarations on entrusting work. This has eliminated unused declarations and rationalized the previous statistics. (3) Seasonal work permits were introduced, issued for a period of up to 9 months and acquired by employers planning to hire a foreigner in agriculture, horticulture, tourist industry and other activities considered seasonal. Both these modifications made the employers' declaration statistics non-comparable with the historical time series before 2018. Especially the introduction of seasonal work permits has disturbed the sector structure of declarations.

reflected in official Labour Force Survey (LFS) data. This is partly due to definition problems – only migrants staying longer than one year are included in the LFS, whereas the (renewable) legal period of stay based on so-called invitations is typically 6–9 months. Furthermore, immigrants are also statistically less likely to participate in surveys than natives.

Crucially, however, this omission – regardless of its causes – has stark consequences for economic growth decompositions using LFS data. The failure to include the inflow of immigrants in estimates of labour supply implies underestimation of growth in the number of workers and total hours worked in the economy and subsequent overestimation of growth in (residual) total factor productivity (TFP). This is a problem that needs to be fixed or otherwise our estimates of sources of economic growth in Poland – and anywhere where immigrants are not included in the official calculation of labour supply – will be systematically biased.

The contribution of the current paper is to impute the labour of immigrant workers from Ukraine – measured in terms of productivity-adjusted hours worked – to the official LFS labour supply data for Poland which essentially represents the labour of Poles. To this end we first construct an estimate of the actual number of immigrants, using a variety of auxilliary sources from the Ministry of Labour, Ministry of Foreign Affairs, the Polish Social Security Institution (ZUS) and the Border Guard, each providing different partial information. Second, to obtain a precise estimate of productivity-adjusted labour supply of immigrant workers we use information on their hours worked and worker characteristics, allowing to identify their productivity. We obtain this information from survey datasets on migrant characteristics, collected by NBP among Ukrainians residing in four Polish cities: Warsaw, Lublin, Wrocław and Bydgoszcz (Chmielewska *et al.*, 2019). The data suggest that migrants, compared to the natives, are characterized by more hours worked but greater concentration in low-skill, low-wage jobs. In particular, they are often employed in occupations below their formal education level (*brain waste*). They are also often remunerated less at equal occupations and with *prima facie* equal skills: the unexplained component of the wage differential is estimated at about 10% (Strzelecki, 2018).[3] In the final step, we plug our imputations into a standard growth accounting procedure and thereby identify the contribution of Ukrainian workers to GDP growth in Poland.

In our baseline case we find that in 2013-18 the arrival of migrant workers from Ukraine increased growth in the effective labour supply in Poland by 0.8% per annum on average. Based on this imputation we infer that the (previously unaccounted) contribution of Ukrainian workers to Poland's GDP growth in 2013-18 amounted to 0.5 pp. per annum on average, or about 13% of total growth. The same figure should be subtracted from the residual contribution of TFP growth, suggesting that recent growth in Poland has been in fact much more labour-intensive than previously interpreted.

As the estimation of magnitude and structure of migration is fraught with uncertainty, we pursue extensive robustness checks of our results. We consider a range of alternative scenarios, making different assumptions regarding the num-

[3]Differences between wages of immigrant and native workers are observed worldwide and do not necessarily reflect wage discrimination defined as different pay for providing exactly the same work. They can also reflect differences in productivity or costs of employment due to, e.g., the shorter experience of immigrant workers in a particular branch or company (firm-specific human capital), instability of contracts, imperfect applicability of knowledge gained abroad to nominally the same occupations in the host country, or linguistic barriers to communication.

ber of migrants, their average hours worked and structure in terms of observable characteristics. This generates a fanchart of possible effects of immigration around the baseline scenario.

The remainder of the paper is structured as follows. Section 2 discusses the associated literature, referring in particular to the available estimates of the contribution of immigrant workers to GDP growth in other countries (e.g., of Polish immigrants to the UK). Section 3 presents the empirical methodology and discusses the data sources. Section 4 handles the uncertainty in measurement of migration by considering a range of alternative scenarios. Section 5 presents the main results and robustness checks. Section 6 concludes.

2 Immigrant workers and economic growth

It is unquestionable that additional immigrant workers contribute to higher total output in the host country. However the effects of immigration for output per capita and labour productivity are *ex ante* ambiguous and may depend on a range of factors.

As a first order effect, the impact of immigration on labour productivity depends on the productivity of immigrants relative to natives. According to the standard Solow model (e.g., Dolado *et al.*, 1994; Barro and Sala-i Martin, 1995) increasing population *ceteris paribus* contributes negatively to per capita growth due to decreasing marginal factor productivity and the dilution of capital. Theoretical works which apply the Solow model augmented by human capital to the context of immigration (see e.g., Dolado *et al.*, 1994) conclude, however, that the more immigrants are educated the more attenuated will be the negative contribution of migration inflow to growth as compared to natural increase in population. This result has been confirmed empirically (see e.g., Ortega and Peri, 2009). In particular Boubtane *et al.* (2016) have shown for 22 OECD countries that the contribution of permanent immigrants to human capital accumulation in the host country tends to dominate the capital dilution effect, even though immigrant workers upon arrival tend to be less productive on average and earn lower wages than natives.

There are also important second order effects. First, the inflow of immigrants creates the so-called *immigration surplus*: as the equilibrium on the labour market is shifted towards lower wages and higher labour supply, firms' gains from immigration tend to exceed workers' losses and the surplus is redistributed in the host economy (Borjas, 1995).[4] Second, immigrants may promote specialization, increase competition on the labour market and bring new ideas – all of which positively influences TFP (Ottaviano and Peri, 2008). In contrast, though, immigration may also cause firms to adopt of less productive technologies which require more unskilled labour (or otherwise postpone the adoption of labour-saving, productivity-enhancing innovations, cf. Lewis, 2005). Capturing the heterogeneity of immigrants' human capital and the utilization of their skills in the economy is therefore crucial for obtaining a reliable estimate of their impact on GDP growth.[5]

[4]General equlibrium effects related in particular to the use of capital, distribution of wages and unemployment in the economy, may overturn this result, though (Chojnicki *et al.*, 2011).

[5]Especially that most of the immigration from Ukraine to Poland after 2014 appears to be circular. Motivations of immigrants are therefore particularly likely to extend beyond

Third, the inflow of immigrants may not just nurture technological innovation, but also – on the negative side – undermine social cohesion and create coordination and communication barriers. Using international data on bilateral migration stocks, Bove and Elia (2017) find that positive innovation and productivity effects systematically prevail, though, and increases in ethnic fractionalization due to foreign immigration tend to have an unambiguously positive impact on real GDP per capita, particularly in developing countries (see also Alesina *et al.*, 2016).

Finally, immigrants may theoretically also substitute natives in the workforce (see e.g. Chiswick *et al.*, 1985), pushing them out of the labour market and increasing unemployment. Empirical evidence firmly rejects this hypothesis, though. Even in jobs where the elasticity of substitution between native and immigrant workers is high the impact of immigration on wages and unemployment among the natives tends to be relatively low (Friedberg and Hunt, 1995). In the OECD there is no Granger causality between the inflow of immigrants and unemployment (Boubtane *et al.*, 2013). In the context of this article it means that we should reasonably expect that the additional workforce of Ukrainian immigrants arriving in Poland since 2014 should have only marginally displaced the Poles, and therefore the additional labour input growth should trace immigration almost one-to-one. The historically low unemployment rate in Poland and very high labour demand in 2014-18 confirm this expectation.

The growth accounting procedure used in this paper is a conventional tool for quantitative assessment of the influence of immigration on economic growth in the host country. However such assessment requires to handle a number of methodological problems. Conclusions of such study can be significantly influenced by, e.g., the composition of migrants in terms of age, sex, education or occupation, the utilization of their skills in the host countries, possible impact of migration flows on the the decisions of firms (for example about the applied technology) and native workers (about labour supply, education, etc.). For this reason publications focusing on the impact of immigration on growth in the host country are quite scarce. An example of a study of this kind is the article by Barrell *et al.* (2010), prepared after the two rounds of EU enlargement in 2004

maximization of income, as explained by *new economics of migration* (see e.g Stark and Taylor, 1991) that emphasizes (i) the role of the reference group in comparing income status, and (ii) prevalence of the household as the decision-making unit. From the macro perspective circular migration offers benefits both for Polish firms (e.g. flexibility of employment) and families of immigrants in Ukraine (e.g. remittances), but it also creates elevated risk of brain waste in the employment of immigrants (Constant *et al.*, 2013).

and 2007. According to the authors' estimates based on a large-scale international economic model NiGEL that simulated the consequences of the changing number of potential employees that moved between EU countries, the economies of Ireland and UK gained from the inflow of immigrants from Central and Eastern European Countries about 1.66% and 0.64% of their respective GDP. More broadly, Aleksynska and Tritah (2015) used a panel of 20 developed OECD countries in 1965–2005 to assess the contribution of foreign immigrants to income of the host countries. Their result is that a 1 pp. increase in the share of immigrants in the working-age population has a highly significant positive effect of about 0.18 pp. in terms of a country's GDP per worker, and 0.12 pp. in terms of its TFP. Similarly, Jaumotte *et al.* (2016) used a panel dataset on migrants to 18 developed OECD countries in 1980–2010 and estimated the impact of migration on the level of GDP per capita. They find that a 1 pp. increase in the share of migrants in the adult population can raise GDP per capita by up to 2% in the long run. Both high- and low-skilled migrants contribute, and the gains from immigration appear to be broadly shared.

3 Method and data

In the current study we first estimate the number of Ukrainian immigrants arriving in Poland over the last decade, then we approximate their productivity-adjusted hours worked, and finally we plug these estimates into a growth accounting exercise. For expositional purposes, though, it is convenient to present our methodology in reverse order.

3.1 Growth accounting

The methodology of our growth accounting exercise follows Fernald (2012a,b) and Gradzewicz *et al.* (2018). We carry out decompositions of the constant-returns-to-scale aggregate production function

$$Y = A \cdot F(Util_K \cdot K(K_1, K_2, ..., K_n), Util_L \cdot L(L_1, L_2, ..., L_m)), \tag{1}$$

based on data on output (i.e. real GDP in base prices as of 2005) of the Polish economy Y as well as the flows of services of inputs: capital K and labour L. Each of these two inputs is itself an aggregate of a number of capital or labour types (n and m types, respectively), differing in their marginal productivity. Flows of capital and labour services are assumed to be proportional but not equal to their stocks. The (time-varying) coefficients of proportionality are the capital and labour utilization rates, denoted as $Util_K$ and $Util_L$, respectively. The aggregate production function is augmented with a Hicks-neutral technological change component A, interpreted as total factor productivity (TFP) adjusted for capacity utilization.

Having denoted the growth rates of the respective variables as $\hat{x} = \ln\left(\frac{x_{t+1}}{x_t}\right)$, the Törnqvist index of output growth is written down as follows:[6]

$$\hat{Y} = \alpha\hat{K} + (1-\alpha)\hat{L} + \widehat{Util} + \hat{A}, \tag{2}$$

where the growth rate of the capital input (services provided by capital) is given by $\hat{K} = c_1^K\hat{K}_1 + c_2^K\hat{K}_2 + ... + c_n^K\hat{K}_n$, the growth rate of the labour input (labour services) is $\hat{L} = c_1^L\hat{L}_1 + c_2^L\hat{L}_2 + ... + c_m^L\hat{L}_m$, and $\widehat{Util} = \alpha\widehat{Util}_K + (1-\alpha)\widehat{Util}_L$ is the weighted average of capital and labour utilization rates. In accordance with the generality of the above Törnqvist index, allowing us to refrain from making exact functional assumptions on the aggregate production function, the components of input aggregates are weighted proportionally to their (time-varying) shares in total remuneration of the respective inputs: c_i^K is the share of remuneration of

[6] See Hulten (2009) for a broad overview of growth accounting methods.

K_i in K, c_i^L is the share of remuneration of L_i in L, α is the capital share of GDP at factor prices.[7] Each of these shares is computed as an arithmetic average of the respective values at times t and $t+1$.

Having backed out the contributions of increases in capital and labour services to GDP growth, we are left with TFP (or Solow residual), which can be further decomposed into two components: the relative change in capacity utilization and a capacity utilization-adjusted measure of TFP growth:

$$\widehat{TFP} = \hat{Y} - \alpha\hat{K} - (1-\alpha)\hat{L} = \widehat{Util} + \hat{A}. \tag{3}$$

TFP growth can be viewed as a difference between growth in output and inputs. However, due to being a residual component, it is also a term where all possible 'other factors' show up: measurement error, time-varying markups, variation in inventories, etc.

Our output growth decomposition rests on the usual set of neoclassical assumptions. Firms in our setup are requested to maximize their profits, with the implication that marginal products are proportional to marginal costs of production. The setup allows for the existence of markups over marginal costs of capital and labour; yet, for the measurement to be consistent, these markups ought to be constant over time.

3.2 The labour composition component

The aggregation procedure used in our study takes into account the differences in unit productivity across the considered capital and labour types, and therefore it should be clearly distinguished from simple summation. Denoting the raw sum of capital inputs as $K_{raw} = K_1 + K_2 + ... + K_n$ and the raw sum of hours worked in the economy as $L_{raw} = L_1 + L_2 + ... + L_m$, we define growth in the *composition component* of capital and labour, respectively, as

$$\hat{Q}_K = \hat{K} - \hat{K}_{raw}, \qquad \hat{Q}_L = \hat{L} - \hat{L}_{raw}. \tag{4}$$

Given that growth in the capital composition component has been essentially zero in Poland since 2000 (Gradzewicz *et al.*, 2018) and the focus of the current

[7] The capital share of GDP is computed based on annual data on GDP at factor prices, gross operating surplus, total compensation of employees, and gross mixed income. We assume that mixed income of proprietors is split into the remuneration of capital and labour in the same proportion as in the rest of the economy. In Poland, the capital income share has exhibited a sharp increase in 2001-04 (from approx. 31% to 39%) after which it has remained roughly constant at the elevated level until 2018.

paper is on labour, in the following paragraphs we will discuss exclusively the labour composition component, Q_L.

Growth in the labour composition component, i.e. the difference between productivity-weighted and unweighted hours worked, captures the dynamic effects of shifts in shares of various types of labour in its total remuneration. More precisely, any increase in the labour composition component should be interpreted as an indication of an observed increase in the share of relatively more productive labour types in the raw labour aggregate. The labour composition component may rise, for instance, due to an increase in the share of (relatively more productive) people with tertiary education in the workforce.

Until 2013 changes in labour composition were the second most important contributor to output growth in Poland, topped only by the accumulation of physical capital. The prime source of this contribution was the massive increase in educational attainment among the Polish population over the last decades. Other considered dimensions of heterogeneity of workers in the Polish LFS – age, gender and sector – were much less potent (Gradzewicz *et al.*, 2018). In the current research we add to that idea in two ways. First, we add citizenship (Polish or Ukrainian) as an additional dimension of stratification. Second, we observe that in the context of defining the status of Ukrainian immigrants on the Polish labour market it is also important to take occupations into account. So in order to measure heterogeneity of workers and hours worked, we stratify workers by their educational attainment, age, gender, sector and occupation. This allows us to draw a clear distinction between raw measures of the labour input (employment, hours worked) and our main variable of interest: the actual flow of labour services, corrected for the differences in labour productivity across employees and workplaces.

More precisely, our approach to capturing changes in labour composition follows Bell *et al.* (2005). It is based on the estimation of means for each of the considered groups of workers. We assume that the growth rate of the productivity-adjusted labour input is given by the following Törnqvist index:

$$\hat{L}_t = \Delta \ln L_t = \sum_{i=1}^{m} \left(\frac{s_{i,t} + s_{i,t-1}}{2} \right) \ln \left(\frac{h_{i,t}}{h_{i,t-1}} \right), \tag{5}$$

where $h_{i,t}$ represents hours worked by workers from group i at time t and $s_{i,t}$ is the share of labour compensation of group i at time t. The weights in the index are given by average shares in the periods t and $t-1$. Growth rates of the composition-adjusted labour input are then obtained as a weighted average of growth rates of total hours worked by groups of workers, with weights given by

their respective shares in total labour compensation. Hence, the productivity-adjusted index grows faster than the unadjusted one if and only if the groups with relatively higher wages experience relatively faster growth in hours worked.

The growth rate of the unadjusted labour input, on the other hand, captures the dynamics of the total number of hours worked, $\hat{L}_{raw} = \Delta \ln H_t$, treating all hours worked as homogeneous. It can also be further decomposed into the growth rate of employment $\Delta \ln E_t$ (the extensive margin) and the growth rate of average hours worked per worker $\Delta \ln \bar{H}_t$ (the intensive margin). Finally, the difference between the growth rates of the productivity-adjusted and unadjusted labour input captures the the contribution of the labour composition component ('quality' of hours worked):

$$\hat{Q}_L = \Delta \ln Q_t = \Delta \ln L_t - \Delta \ln H_t = \Delta \ln L_t - \Delta \ln \bar{H}_t - \Delta \ln E_t. \tag{6}$$

Using the properties of the Törnqvist index, we also calculate the separate contributions of each of the worker features taken into account (citizenship, educational attainment, age, gender, sector, occupation) to the growth of the productivity-adjusted labour input. For example, the partial 'education-specific' labour composition component, capturing the differences between groups according to their educational attainment but ignoring all other dimensions of worker heterogeneity, is computed as:

$$\Delta \ln Q_t^{Edu} = \Delta \ln L_t^{Edu} - \Delta \ln H_t. \tag{7}$$

This is called a *first order partial index* of characteristic i. Since the current study singles out six distinct labour force characteristics, we compute six partial indexes of this kind. Among them, of particular interest to the current paper is the decomposition of labour input growth into the contributions of native and immigrant workers:

$$\hat{L} = \hat{L}^{PL} + \hat{L}^{UA} = \hat{L}_{raw}^{PL} + \hat{L}_{raw}^{UA} + \hat{Q}_L^{PL} + \hat{Q}_L^{UA}. \tag{8}$$

In principle, one could also consider individual contributions of combinations of (two or more) worker features, leading to the calculation of second- and higher-order labour force productivity decompositions. However, they are of relatively minor importance for the results of the current study and thus we set them aside.

3.3 Data sources

We use Polish Labour Force Survey (LFS) microdata from Statistics Poland to describe the size and characteristics of employment of Polish citizens. This

dataset contains representative and most comprehensive information regarding the labour market in Poland in the period 1995-2018. The quarterly sample size in the LFS varies between 50 and 100 thousand individuals (Statistics Poland, 2018). Unfortunately, information about individual wages needs to be interpolated as some persons answer only categorical questions about their income and some refuse to answer this question completely.

In spite of the value of LFS as a source of information about native workers, it covers only a minor part of the immigrants who live and work in Poland. This is because by definition the LFS survey is addressed to persons who live in Poland for at least one year while majority of immigrants stay in Poland for shorter periods only because of the most popular short-term visas. According to both Ukrainian sources and Polish surveys only about 6% of immigrants from Ukraine had long-time work contracts in the beginning of 2017 (Chmielewska *et al.*, 2018). Another reason for the absence of immigrants in the Polish LFS is their geographical mobility (even if migrants stay in Poland long enough to be included they relatively frequently change their place of residence) and reluctance to participate in surveys, as well as a relatively high incidence of living in collective households, which are in practice excluded from the LFS. In the period 2014-16 in Polish LFS there were only 82 immigrants who filled the questionnaire including the information on their wages and hours worked. At the same time the number of immigrants observed in the Polish economy increased to around one million, so proportionally hundreds of immigrants should have been observed in every quarter of the sample of a study as big as LFS.[8] It is therefore clear that Ukrainian immigrants are largely underrepresented in LFS. To impute them we use other available official data sources.

Although there is no one comprehensive dataset on immigrants to Poland, the

[8]Increased immigration is only one of the phenomena that have influenced the labour market in Poland since 1995 but are not fully reflected in the LFS. The remaining two are changes due to population aging and emigration of Polish workers after the EU accession. In both cases the censuses in 2002 and in 2011 allowed to adjust the population size and structure used to weight LFS results but the adjustments have been done only to few years and not the entire period between censuses. Another problem are the discontinuities caused by methodological changes. The underestimation of emigration of Polish citizens in the Labour Force Survey data published before 2010 has been caused by the imperfect definition of migrants used by Statistics Poland in the past. This has been corrected after the census in 2011 and now the definition (consistent with Eurostat requirements) should reflect the changes of the number of emigrants. However, the data have not been corrected backward before 2010 in Statistics Poland and Eurostat publications. In this paper we use the most reliable estimates of the necessary corrections of LFS data (Saczuk, 2014) to correct the weights of the LFS datasets.

requisite information can be recovered from a variety of fractional data sources capturing different aspects of migration, with different coverage and definitional caveats. In order to estimate the true number of immigrant workers in Poland as close as possible, one should be aware of all their strengths, drawbacks and specificities.

We use the following datasets. First, raw data published by Ministry of Labour (see Figure 1) refers to the number of declarations on entrusting work to foreign workers as well as to work permits issued during the year. Not all declarations, however, end with an employment contract. One immigrant is also allowed to receive declarations from several different employers. Moreover, the average duration of work on the basis of such a declaration amounts by definition only to half a year. This is why that measure strongly overestimates the effective headcount of immigrants and needs to be corrected in order to reflect reliably the immigrant labour force. Second, Polish Border Guard data on border crossings constitute another publicly accessible source of information about the intensity of migration movements. They complete the picture of immigration flows to Poland, while contributing to the assessment of tendencies, although they are hardly applicable to identify the scale of migration which is predominantly circular. Third, another useful data source is the number of foreign citizens paying their social contributions to the Polish social security system. The share of short-term migrants in Poland considered by the Polish Social Security Institution (ZUS) is systematically increasing. Nonetheless, the share of foreign citizens working on the basis of civil law contracts not covered by ZUS, especially those combined with employer's declarations, remains relatively high, which makes the calculation of immigrants based exclusively on that data source still incomplete[9]. Fourth, according to Statistics Poland estimates based on the capture-recapture method applied to selected micro databases that contain the information about immigrants (Szałtys *et al.*, 2018) the number of immigrants in Poland at the end of 2015 amounted to 488 thousand and at the end of 2016 to 720 thousand. The width of 95% confidence intervals for these estimates (between 355 and 699 thousand in 2015 and between 580 and 915 thousand in 2016), however, underscores the high uncertainty in analyzing migration flows. Apart from wide confidence intervals the problem with this estimate is that Statistics Poland focuses on the population at the end of the year but what matters from the perspective of economic growth is the average number of persons during the year

[9] According to ZUS data the number of foreign citizens paying their social contributions to the Polish security system was 644 thousand, of which 483 thousand Ukrainians as for 30 June 2019.

who are engaged on the Polish labour market. For all these reasons, we treat these sources as only auxilliary and proceed to construct our own estimates of the number of Ukrainian immigrants in Poland.

Our information on the socio-demographic structure of immigrants from Ukraine comes from immigrant surveys carried out by NBP using respondent driven sampling (RDS) in selected cities in Poland: Warsaw, Lublin, Bydgoszcz and Wrocław (Table 1). In total 1920 interviews have been carried out but only 1536 of them covered employed persons who answered all questions about wages, hours worked, personal characteristics (sex, age, educational level) and description of the workplace (economic sector, occupation).[10] RDS was used in order to cope with the important problem that for short-term immigrants the sampling frame is not available (Heckathorn, 1997).[11] Naturally, the representativeness of data from selected places in Poland for the entire population of Ukrainians in Poland can be legitimately questioned, but better data are not available and at least we know that since 2014 a large fraction of the new immigration is observed in the sectors highly present in big cities while the share of agriculture is declining (see Figure 1). In our assessment the information obtained from the NBP survey dataset is comprehensive enough to create the profiles of hours worked and wages required in the analysis but is insufficient to reconstruct the dynamics of these indicators over time, in which case the sample size would become too small in comparison to the required cross-tabulations. That is why in our analysis we calculate hours worked and hourly wages of immigrants for pooled data only and assume that these profiles have been constant over time.

Unfortunately, application of publicly avaliable data regarding the structural characteristics of immigrants (e.g., sector structure, presented in the Figure 1) was not possible because some information (like the cross-tabulations by sex, educational attainment or occupation) was inavaliable. Reassuringly, though, the avaliable official data (like the sector structure) is broadly consistent with NBP survey estimates, except for the share of employment in agriculture which is

[10]Information about workplaces has been collected from descriptive questions in order to avoid misunderstandings which are frequent when using the official classification of occupations and sectors. However information collected from the survey was sufficient to recode answers to the official classification in the database.

[11]RDS allows to control the process of recruitment of respondents and create weights to balance the results. In addition the method of conducting the interviews assures the best possible conditions to collect unbiased information on sensitive issues by: ensuring anonymity, using safe places outside immigrants' work or households, translating questionnaires to the native language of immigrants, paying small amounts of money for the time spent on the interview and helping in further recruitment.

Table 1: Description of samples of immigrant surveys

	Warsaw	Lublin	Bydgoszcz	Wrocław
Year	2015	2016	2018	2018
Sample size	710	400	310	500
Effective sample size	540	310	297	389

Source: Own calculations

very sensitive to the time-varying institutional setup (see Table 2 for comparison).

Table 2: The structure of emplyment by non-agriculture sectors relative to the non-agricuture total (in %)

Sector	NBP surveys	ML*(2018)	ML*(2016)	ZUS** (2018)
Non-agriculture total	100	100	100	100
Manufacturing	23	38	17	15
Construction	13	21	17	12
Market services	56	38	57	60
Non-market services	8	3	9	13
Agriculture***	7	1	55	-

Source: Own calculations based on NBP surveys

Notes: * ML – Ministry of Labour data on work permits and declarations to entrust jobs to immigrants, **ZUS - National Insurance Institution data on the contributions of foreign citizens employed in Poland, *** for comparison, agriculture presented as a separate sector and expressed as a percentage of non-agriculture employment

The data on Poland's annual GDP, gross fixed capital formation and its breakdown, and factor shares have been taken from Eurostat. The procedure for computing the productivity-adjusted stock of physical capital is exactly the same as in Gradzewicz *et al.* (2018).

4 Imputation of immigrant labour supply

In order to impute the (hitherto unaccounted) labour supply of Ukrainian immigrants to Poland, we need to make firm assumptions on the following issues: (i) the number of immigrant workers, (ii) the structure of hours worked per immigrant worker, and (iii) their productivity. Unfortunately, there is substantial uncertainty in all three dimensions, and therefore we must consider a number of alternative scenarios. We consider (i) two main scenarios (and two additional robustness checks) for the number of immigrant workers, and (ii)–(iii) one main scenario plus four robustness checks for their structure and productivity.

4.1 Number of immigrant workers

According to a recent OECD report (OECD, 2019) in 2017 Poland was among the countries with the highest number of temporary working immigrants, estimated at about 1.1 million. Similar numbers can be found also in other sources such as NBP communication (DAE-NBP, 2019) or a report by Selectivv based on cell phone data (Czubkowska, 2019). In this paper we use two alternative approaches to estimating the average number of immigrants from Ukraine employed in Poland in each year.[12] Aggregate numbers produced by both of them are in the same ballpark (either 0.9 or 1.1 million Ukrainian immigrants in 2018), but there is a noticeable difference in dynamics. Figure 2 presents the comparison of the estimates obtained in our baseline scenario and an alternative one.

In the *baseline* scenario the number of Ukrainians has been calculated on the basis of data about the number of different types of visas, residence permits issued to immigrants and additional data on the average time spent by them in Poland taken from survey data (Górny *et al.*, 2018). The advantage of this approach is the reduction of the problem of double counting of the same persons, as both visas and residence permits are always assigned to one single person. Unfortunately this estimate is based on the data from Ministry of Foreign Affairs which is not publicly available. This approach also excludes persons who used to work in Poland illegally either on the basis of their touristic visas before EU visa liberalization (June 2017)[13] or on the basis of a biometric passport (which

[12] It should be emphasised that it is not the total number of immigrants (not all immigrants are employed) or the number of immigrants in a certain moment of the year (due to seasonality it will depend on the choice of month).

[13] The decision to transfer Ukraine to the list of third countries whose nationals are exempt from the visa requirement came into effect on 11 June 2017. From this date, the visa obligation for citizens of Ukraine who hold a biometric passport and want to travel to the Schengen zone

allows for stays up to 3 months), so it omits this part of illegal employment and stay. Since July 2017 the estimated number of working immigrants from Ukraine has been complemented with immigrants coming within the course of the visa free regime for the purpose of work, mostly being legally employed on the basis of employer's declaration. In this scenario we assume that the number of immigrants employed in the Polish economy before 2002 was negligible (only several thousands) but it increased somewhat after 2007 when liberal regulations of employment in agriculture were introduced. After 2013, during the current surge of immigration the average annual number of immigrants who work in the Polish economy has increased from nearly 200 thousands in 2013 to almost 900 thousands in 2018. Respectively the share of immigrants in the Polish labour supply has increased from less than 1% before 2013 to more than 5% today.

Our *alternative* scenario is based on the publicly available data about different types of documents that enable Ukrainian citizens to stay in Poland and some assumptions about harmonization of this data (in particular we assume that all persons with work permits regularly pay contributions to ZUS). Here also additional information from surveys is needed in order to define the time of stay and work. This estimate takes into account also formally illegal work (for example of persons entering Poland only with touristic visas or biometric passports). The drawback of this approach is the possibility of double counting of the same persons during the year. According to this estimate the wave of immigration after 2014 was much sharper and the number of immigrants from Ukraine who worked in Poland in 2018 was close to 1.1 million.

In order to measure the possible consequences of uncertainty in measuring the number of immigrants we have also added two robustness checks in which the size of immigration is systematically 20% lower or 20% higher than the baseline.

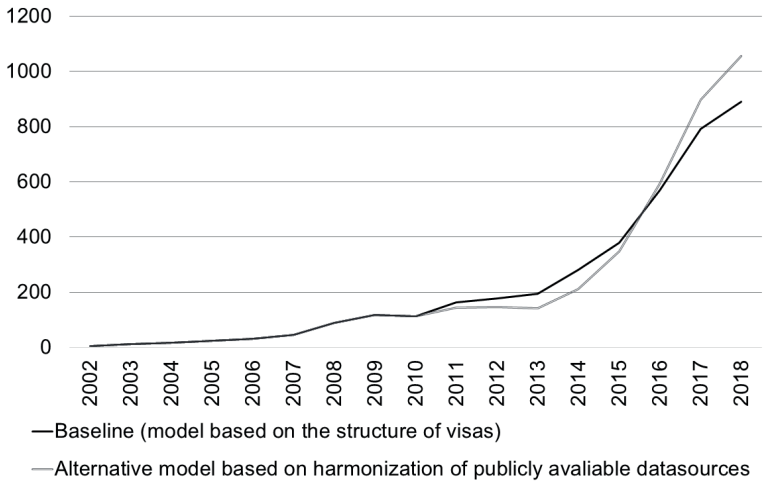
4.2 Heterogeneity of socio-economic features of workers

The impact of immigrants on economic growth depends on their productivity, which in turn depends on their socio-demographic features and characteristics of their workplaces. In this paper we stratify immigrants by sex (2 groups), age (4 groups), educational attainment (3 groups), sector of employment (3 groups) and occupation (3 groups). Thereby we consider in total $2 \cdot 4 \cdot 3 \cdot 3 \cdot 3 = 216$ combinations of features, separately for native and immigrant workers. For each of these combinations we calculate average hours worked and average wage.

General information about socio-economic features of immigrant and native

for a short stay was abolished.

Figure 2: Comparison of estimates of the average number of employed immigrants from Ukraine in the Polish economy during the year



Source: Own calculations

workers is presented in Table 3. There are significant differences in the proportions of immigrants and native workers with respective characteristics. First, the share of women in the sample of employed immigrants is somewhat higher than in the total population of Polish employees. Second, the immigrants were on average much younger: 36% of immigrant workers were younger than 25 years compared to only 6% of Polish employees in 2018. Third, the immigrants were on average better educated: 51% declared completed tertiary education in comparison to 35% of the Polish working population in 2018. At the same time the share of persons with primary and basic vocational attainment among immigrants (9%) was relatively low compared to Polish employees (30% in 2018). What differentiates immigrant and native workers most, though, is the very low employment of immigrants in top occupations (managers an specialists) and a relatively very high share of persons employed in bottom occupations where specific skills are not required. Only 8% of immigrants worked as managers or specialists while 56% were employed in bottom occupations.

4.3 Heterogeneity of average hours worked and productivity

The aggregation method used in this paper measures the labour input in hours and approximates the value of that input by average wages of workers. That

Table 3: Characteristics of immigrant and native workers (in %)

Variable	Immigrants	Natives in 2018	Natives in 1995
Sex	100	100	100
Male	47	53	55
Female	53	47	45
Age	100	100	100
15-24	36	6	10
25-44	53	61	69
45-59/64	10	27	15
60/65+	1	6	5
Educational attainment	100	100	100
Tertiary	51	35	10
Secondary	40	35	33
Primary and basic vocational	9	30	57
Sector	100	100	100
Industry	19	16	31
Agriculture and construction	22	24	25
Services	59	59	43
Occupation	100	100	100
Managers and specialists	8	27	14
Middle	36	43	45
Bottom	56	30	41

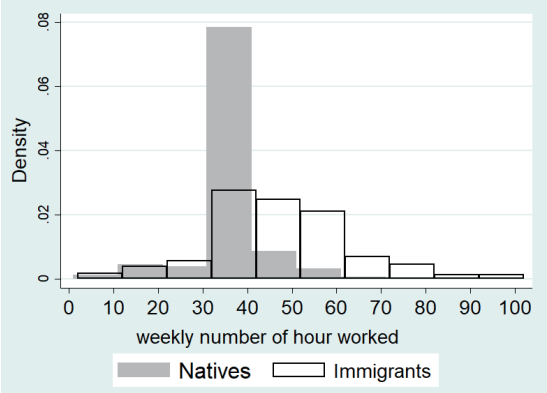
Source: Own calculations based on NBP surveys and LFS

is why the differences in average hours worked by immigrants and wages of immigrants in relation to Polish workers are important not only for the total population but also in the case of the 216 groups taken into account in our analysis. Mean values of these variables among immigrants relative to native workers, broken down by sex, age, education, sector and occupation, are presented in the Table 4. Average hours worked by immigrants are markedly higher than by Polish workers but their hourly wages are lower. The wage gap of about 10% between native and immigrant workers remains in place even if the results are controlled for the available features of persons and their workplaces (Strzelecki, 2018), and it can be considered a measure of relative productivity of immigrant workers in comparison to native workers unexplained by the variables used also in this study – at least under the assumption of no systematic wage discrimina-

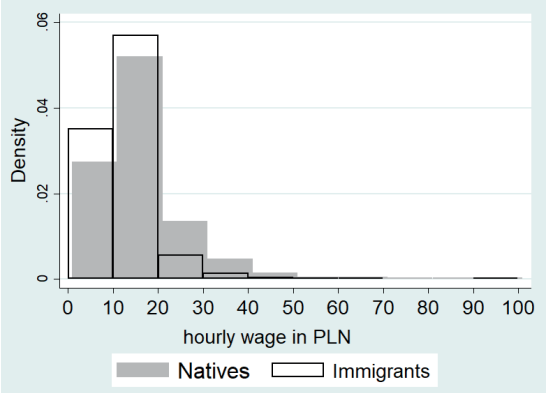
tion. This discrepancy is also visible (Figure 3a, Figure 3b) when we compare the distributions of average weekly hours worked and average hourly wages.

Figure 3: Comparison of distributions of average hourly wages and average hours worked between between immigrant and native workers

(a) average hours worked



(b) average hourly wage



Source: Own calculations

4.4 Definition of the scenarios

We know for sure that labour supply is underestimated in Polish LFS due to not taking into account the labour services provided by immigrants. Imputation of this additional labour involves uncertainty, though, and this uncertainty pertains not just to the number of immigrants but also their structure and productivity. In this regard, our baseline decomposition takes into account the features mentioned in Tables 3 and 4: sex, age, educational attainment, sector of employment and occupation category. Nevertheless, in order to truly understand the importance of the heterogeneity of immigrants it seems inevitable to check also four scenarios where the assumptions about the differences between natives and immigrants are partially relaxed:

(a) *same hours* – in which the average hours worked of all groups of immigrants are exactly the same as for native workers,

(b) *same structure* – in which average hours worked and wages are different but the proportions of the groups defined by the features are the same as for natives,

Table 4: Relative wages and relative hours worked of immigrants in comparison to native workers by worker characteristics

Variable	Relative hours worked	Relative hourly wages
Total	1.427	0.781
Sex		
Male	1.385	0.743
Female	1.483	0.852
Age		
15-24	0.888	0.989
24-44	1.445	0.816
45-59/64	1.356	0.612
60/65+	1.843	0.459
Educational attainment		
Tertiary	1.378	0.689
Secondary	1.311	0.841
Basic and vocational	1.278	0.974
Sector		
Industry	1.356	0.702
Agriculture and construction	1.311	0.841
Services	1.278	0.781
Occupation group		
Managers and specialists	1.052	0.868
Middle occupations	1.231	0.851
Bottom occupations	1.269	0.926

Source: Own calculations based on NBP surveys and LFS

(c) *same wages* – where hours worked and features of immigrants are different but wages of persons with certain features are always the same as among natives, and

(d) *all equal* – where features of immigrants, their working hours and wages are exactly the same as among natives.

The last scenario is a 'naive' counterfactual where all labour input growth due to immigration is attributed to the additional employment of immigrants, as if only the headcount mattered.

5 Results

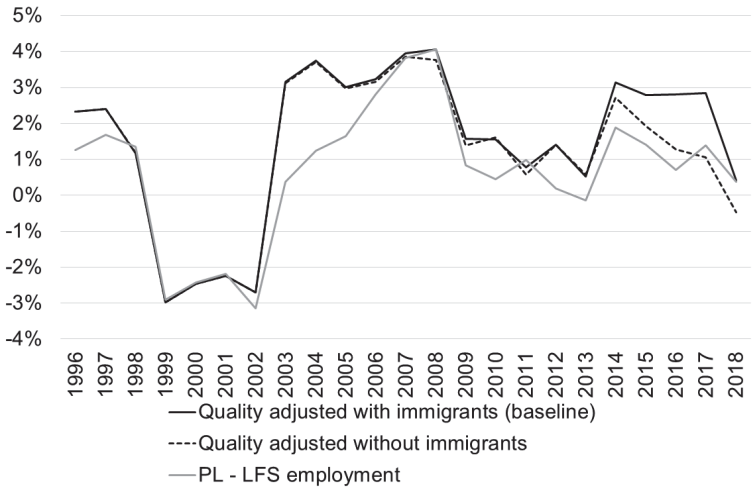
We will now present the results of our study. First, we will cover our baseline scenario, comparing it with a null scenario that disregards the labour of immigrant workers. Second, we will consider our alternative scenario for the number of immigrants and the two associated robustness checks. Third, we will discuss the importance for the results of differences between immigrants and natives in terms of hours worked, hourly wages, and socio-economic structure. Finally, we will present our estimates of the impact of imputed immigrant labour on Polish GDP growth.

5.1 Labour input in the baseline scenario vs. the null scenario without immigration

Our baseline estimates of the labour input, which take into account both the quantity and productivity of hours worked, confirm a large positive impact of immigration from Ukraine on total labour supply in Poland in 2013-18 (Figure 4, Table 5). Although growth in the labour input of the native Polish population has slowed down considerably after 2014, immigration filled most of the ensuing gap, sustaining labour input growth rates above 2% per annum until 2017 and cushioning a major part of the decline in 2018. A decomposition of this result shows that the impact of the growing number of immigrant employees was particularly important in the years 2014-2017 when it added 0.5-1.3 pp. to annual labour input growth in Poland. On top of that, relatively longer average working hours of immigrant workers contributed an additional 0.1-0.3 pp. per annum. The structural make-up and average productivity of the immigrant labour force, in turn, corrected the overall impact downwards by about 0.1 - 0.3 pp. per annum.

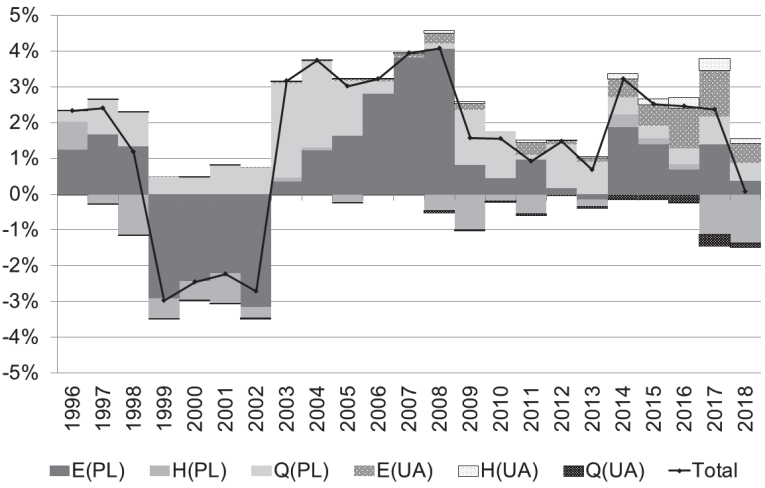
A further decomposition allows to observe which features of all workers (Figure 6a) and immigrants (Figure 6b) have been most important for determining the contribution of their structure to overall (productivity-adjusted) labour supply growth. We find that the slightly negative contribution of the socio-demographic structure of the immigrant worker population is primarily due to the fact that Ukrainians are heavily overrepresented in bottom occupations and underrepresented in the group of managers and specialists (Figure 6b). Another important contribution comes from the relatively lower average age of Ukrainian workers – as a general rule wages of younger persons tend to be lower. After controlling for occupational structure and age, though, other features of immi-

Figure 4: Annual labour input growth – effects of including additional information



Source: Own calculations

Figure 5: Annual labour input growth – decomposition of baseline



Source: Own calculations. E: number of employees; H: hours worked per employee; Q: composition of hours worked. PL: Polish workers; UA: Ukrainian workers.

grants like the relatively high educational attainment and a relatively high share of females had very limited impact.

When including also the structure and productivity of the native population in the decomposition (Figure 6a), our results are in good agreement with Gradzewicz *et al.* (2018). We confirm that the increasing educational attainment

Table 5: Decomposition of annual growth rates of the labour input in the period 2013 – 2018 (in %)

Year	Total	E(PL)	H(PL)	Q(PL)	E(UA)	H(UA)	Q(UA)
2014	3.2	1.9	0.3	0.5	0.5	0.1	-0.1
2015	2.5	1.4	0.2	0.4	0.6	0.2	-0.2
2016	2.5	0.7	0.1	0.4	1.1	0.3	-0.2
2017	2.4	1.4	-1.1	0.8	1.3	0.3	-0.3
2018	0.1	0.4	-1.4	0.5	0.6	0.1	-0.1
Average*	2.1	1.1	-0.4	0.5	0.8	0.2	-0.2

Source: Own calculations, *: The average growth rate in the last five years. The year 2013 is treated as the base year. E: number of employees; H: hours worked per employee; Q: composition of hours worked. PL: Polish workers; UA: Ukrainian workers.

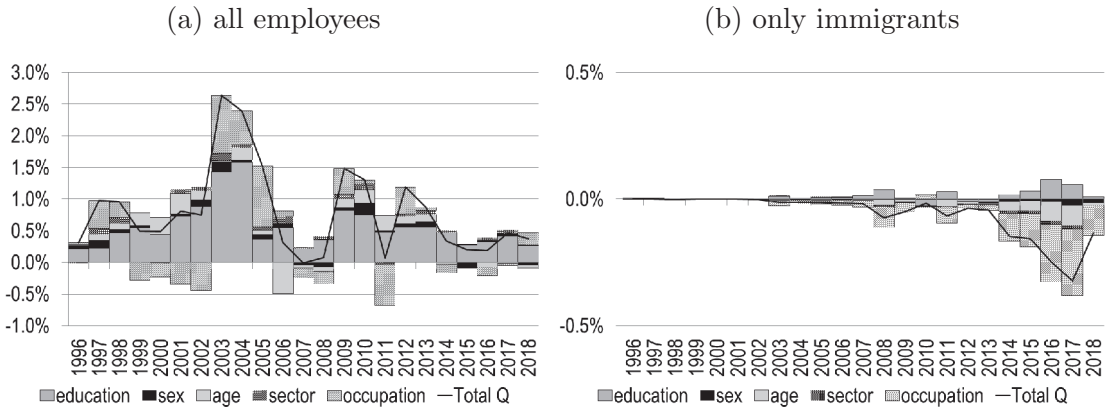
of Polish workers due to the replacement of older and less educated generations by new better educated generations provided a key contribution to overall labour supply growth. A smaller positive contribution was also provided by the age component, reflecting primarily population aging, as well as the reform of early pensions in 2009 and the gradual extension of the retirement age until 2017. A new finding of the current study pertains to the impact of the relocation of employees between occupations, related to structural changes in the economy. In general the impact of this factor was positive over the last 25 years but there were also isolated periods of negative changes.[14]

5.2 Robustness checks with respect to the number of immigrants

To confirm reliability of our baseline results, we have checked their sensitivity to different assumptions about the number of immigrants. The question here is, what would happen if the number of immigrants was in fact lower or higher

[14]Following the Russian crisis in 1998, Polish exporting firms were forced to re-orientate from from Eastern to Western markets. This shift required a restructuring of the economy and resulted in a period of very high unemployment (years 2000-2002). At that time also the contribution of occupational structure to productivity-adjusted labour supply growth was negative. Negative contributions of occupational structure were observed also during booms in the construction sector (years 2007-2008 and 2011) when dynamic wage growth in relatively less skilled jobs in this sector attracted employees from other occupations.

Figure 6: Decomposition of the impact of heterogeneity of employees on results



Source: Own calculations

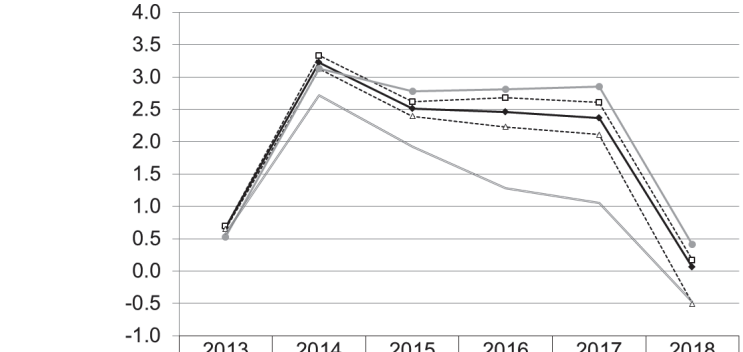
than assumed in our baseline estimate? As mentioned earlier we consider four scenarios in this regard: baseline, an alternative scenario, and two sensitivity tests artificially shifting the baseline upwards or downwards by 20% throughout the entire path.

The results suggest (Figure 7) that the main conclusions inferred from our baseline scenario are robust. In all scenarios except the null variant without migration, labour input growth in the period 2015-2017 remained lower than in the peak of 2014 but still above 2% and relatively stable. A slowdown was observed only in 2018. Although all scenarios show similar patterns over time, the growth rates are quantitatively different. The highest ones are observed for the *alternative* scenario which takes into account illegal employment of immigrants. According to this view – as well as the sensitivity test that assumes 20% higher immigration than in the baseline – immigration inflow was more than enough to counterbalance the negative impact of weak employment growth and sharp decline in average hours worked among native workers in 2018, so that overall annual labour input growth amounted to +0.3% in that year. In other scenarios annual labour input growth rates were closer to 2% in the period 2015-2017 and slightly negative in 2018.

5.3 The role of heterogeneity of immigrants

The baseline scenario assumes that proportions of certain types of workers (216 groups) are different among immigrants than among natives. In addition average hours worked of immigrants are higher than of native workers but there are

Figure 7: Annual labour input growth under four scenarios regarding the number of immigrants



	2013	2014	2015	2016	2017	2018
Baseline	0.7	3.2	2.5	2.5	2.4	0.1
Baseline +20%	0.7	3.3	2.6	2.7	2.6	0.2
Baseline -20%	0.7	3.1	2.4	2.2	2.1	-0.5
Alternative	0.5	3.1	2.8	2.8	2.9	0.4
No migration	0.6	2.7	1.9	1.3	1.1	-0.5

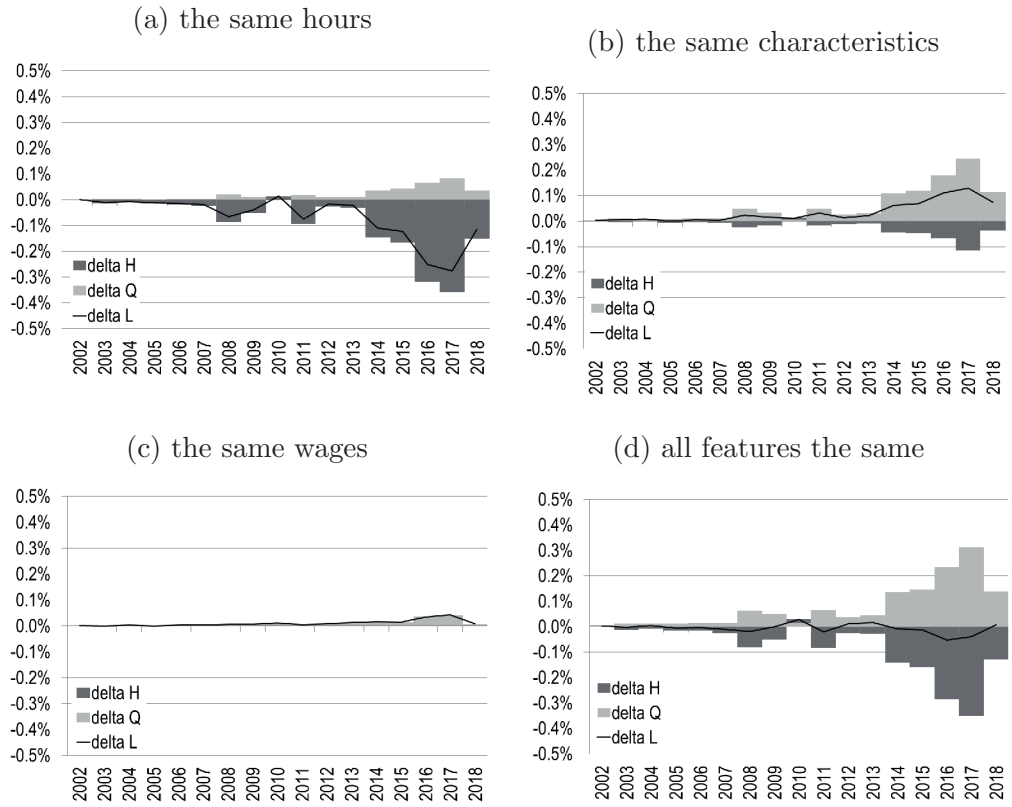
Source: Own calculations

also large between-group differences. Finally, hourly wages of immigrants are on average lower than the wages of natives and also quite heterogeneous. In order to quantify how these assumptions influence our baseline results we have considered four scenarios where the assumptions between immigrants and natives were partially relaxed:

(a) *same hours*: if we assume that there are no differences between hours worked of native and immigrant workers, it leads on average to a lower impact because on average immigrants work longer hours (Figure 8a). The main effect is however partially counterbalanced by a composition effect: total hours worked by immigrants are now a lower fraction of total hours in the economy and therefore the detrimental effect of relatively lower wages of immigrants is now lower;

(b) *same structure*: in comparison to Polish workers immigrants are on average younger and work in worse paid (less productive) occupations. What would happen if the proportions of immigrants and natives in all analyzed groups were the same but differences in average hours worked and hourly wages remained intact? The labour input would then be higher due to the higher mean age of the imputed workers and their employment in more productive occupations, even though average working hours would then be slightly lower (figure 8b);

Figure 8: Robustness checks – the impact of the suspension of differences between Ukrainian and Polish workers by selected features in comparison to the baseline with all differences included



Source: Own calculations

(c) *same wages*: in the baseline scenario the lower average wage of immigrants is both due to their characteristics and the unexplained native-immigrants wage gap. Earlier analysis for the immigrants in Poland showed that this unexplained gap is close to 10% (Strzelecki, 2018). However what would happen if we assumed that there was no difference between Polish and immigrant workers inside the groups that describe the heterogeneity of the workforce? Figure 8c suggests that the effect is minuscule: a higher assessment of the productivity of immigrants in comparison to Polish workers in the same occupations would contribute at most 0.1 pp. per annum to overall labour supply growth;

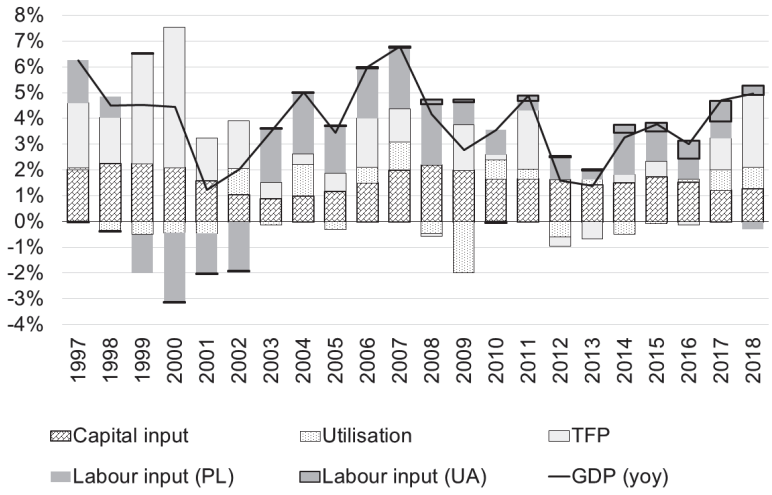
(d) *all equal*: finally, we analyze the scenario in which all features of immigrants would be the same as of Polish workers and in addition in all analyzed categories they would earn the same wages and work the same average

number of hours. In such a scenario labour input growth would be only marginally faster than in the baseline scenario because gains in labour productivity due to a more productive workforce and better wages will be offset by lower average working hours (figure 8d).

5.4 Growth accounting with immigration

Our estimates of the labour input presented in the previous sections will now be plugged in growth accounting. As argued before, until 2014 the impact of immigration on GDP growth in Poland remained negligible (below 0.1 pp., Figure 9). Since 2014 the contribution of the labour input of immigrants rapidly grew, though, becoming a significant part of Poland's growth potential. In the period 2013-2018 the contribution of the inflow of Ukrainian workers to Poland's GDP growth ranged between 0.3 pp. to 0.8 pp. per annum (0.5 pp. per annum on average), so that the inflow of Ukrainian workers was responsible for about 13% of economic growth in Poland in 2013-18. In fact in 2016-18 growth in the labour input of immigrants contributed to GDP growth more than the impact of growth in the labour input of Polish citizens.

Figure 9: Decomposition of GDP growth including the distinction between contributions of the native (PL) and immigrant (UA) workforce



Source: Own calculations

Looking at a longer time frame, the aggregate contribution of Ukrainian immigrants to Poland's GDP growth (Table 6, 7 and Appendix Table 10) in the entire period 1996-2018 amounted to about 3%, compared to the contribution

Table 6: Contributions of main factors to economic growth in Poland

	1996*-2018		2013*-2018	
	Without immigrants	Baseline	Without immigrants	Baseline
K	41.8	41.8	35.3	35.3
L (PL)	17.9	17.9	13.9	13.9
L (UA)	0.0	3.8	0.0	13.3
Util	1.5	1.5	9.9	9.9
TFP	38.8	35.1	40.9	27.6

Source: Own calculations, * Base year

Table 7: Decomposition of annual GDP growth (in %) in the baseline scenario, 2013*-2018

Year	GDP (yoy)	Capital input	Labour input (PL)	Labour input (UA)	Utilisation	TFP
2014	3.3	1.5	1.6	0.3	-0.5	0.3
2015	3.8	1.7	1.1	0.3	-0.1	0.6
2016	3.0	1.5	0.8	0.7	0.1	-0.1
2017	4.7	1.2	0.7	0.8	0.8	1.2
2018	5.0	1.3	-0.3	0.3	0.8	2.8
Average*	3.9	1.5	0.8	0.5	0.2	1.0

Source: Own calculations. *: The average growth rate in the last five years. The year 2013 is treated as the base year.

of labour input of Polish workers of about 18%. However when we focus only on the recent years (2013-18), the contributions of immigrants and natives are almost at par: about 13% of total economic growth was due to immigrant labour input growth while about 14% was due to labour input growth of natives.

Our baseline estimates are subject to uncertainty, though, both in terms of the actual number of immigrant workers from Ukraine in Poland, and their structure and productivity. Table 8 demonstrates that the possible magnitude of impact ranges from about 9% of GDP growth in 2013-18 in our most conservative scenario (baseline minus 20% immigration) to 19% in our *alternative* scenario outlined in the previous section. As documented in the Appendix Table 11, bulk of the difference is realized in the period of most dynamic immigration, 2015-17, and outside of the time bracket 2013-18 the contribution of immigrant labour to Poland's GDP growth was very small across all scenarios, ranging from zero to at most 0.2 pp. per annum.

Table 8: Robustness of the results - the contributions of main factors to economic growth in Poland

	2013*-2018			
	Baseline	Alternative scenario	Baseline - 20%	Baseline + 20%
K	35.3	35.3	35.3	35.3
L (PL)	13.9	13.9	13.9	13.9
L (UA)	13.3	18.7	8.9	15.8
Util	9.9	9.9	9.9	9.9
TFP	27.6	22.2	31.9	25.1

Source: Own calculations, * Base year

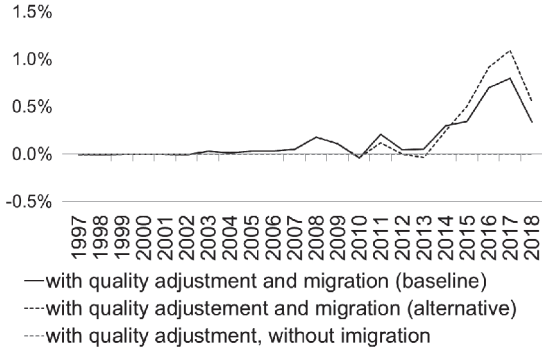
Imputation of the labour input of immigrants has important consequences for the assessment of total factor productivity (TFP) growth in the Polish economy which is computed residually. According to our baseline findings, in 2013-18 the contribution of TFP growth to GDP growth amounted probably not 41% (which would be obtained if the labour of Ukrainian immigrants were disregarded) but about 28%. In the whole period 1996-2018, after our imputations the contribution of TFP growth is corrected downwards from 39% to 35%.

This means that having factored in the contribution of immigrant workers from Ukraine, the last five years were in fact characterized not by above-average, but below-average contribution of TFP to economic growth in Poland. In reality,

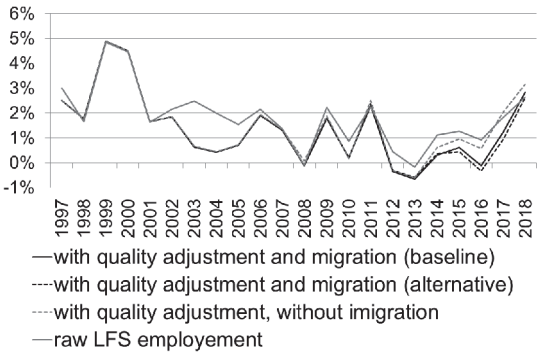
recent growth was in fact much more labour-intensive, and much less technology-driven than previously interpreted. In 2013-15 the contribution of TFP growth to GDP growth was very low at below 1 pp. per annum, in 2015-16 it was none at all, and it picked up only in the last two years, 2017-18 (Figure 10).

Figure 10: Impact of the correction of the labour input in the Polish economy on annual growth of GDP and TFP

(a) Contribution of immigration to GDP growth



(b) TFP growth under different migration scenarios



Source: Own calculations

6 Conclusions

Large-scale immigration of Ukrainian citizens to Poland after 2013 is an unprecedented phenomenon in Poland's modern history. This paper sheds new light on one of its important effects: the impact on economic growth in Poland. Unfortunately, earlier decompositions of economic growth in Poland did not account for the inflow of immigrants, thereby systematically underestimating the contribution of the labour input and overestimating the role of TFP. This is a problem which our paper aims to rectify. We do this by imputing the labour supply of Ukrainian workers, estimated with the help of a number of auxilliary data sources. We believe this is an important contribution to the literature not only looking from the Polish or Ukrainian perspective, but also more broadly because similar problems are likely to arise also in other countries witnessing rapid immigration.

According to our baseline estimates in the peak of immigrant inflow (2016-17) economic growth in Poland was increased by additional 0.7–0.8 pp. in each year due to immigration. More broadly, in the period 2013-2018 immigration contributed on average about 0.5 pp. per annum, or 13% of total GDP growth in the Polish economy. Estimates presented in this paper also show that when the labour input is corrected for immigration, residual TFP growth is significantly less important in explaining GDP growth. This suggests that recent growth in Poland has been in fact much more labour-intensive than previously interpreted.

By taking into account the heterogeneity of labour supply in the economy this paper also proposes a method of assessment of the role of human capital of immigrants in the host country. The method allows to take into account not only the skills of immigrants (their educational attainment, and age as a proxy for work experience) but also the level to which these skills are utilized (occupations and wages of immigrants in comparison to natives). Majority of immigrants all over the world tend to work in bottom occupations in the host countries even if they are university graduates. A similar tendency is observed in Poland; its influence on total labour input growth seems to be relatively limited, though. The simulation under the assumption that the immigrants would have the same features and the same productivity as the Polish workers resulted in a higher total labour input growth of only about 0.3 pp. in the peak year 2017.

The analysis carried out in this paper has two main limitations. The first is the availability of reliable data about immigrants in Poland and their characteristics. The available data in this respect are rather limited and official estimates do not exist. We fill this gap with our own calculations based on different data

sources, including in particular dedicated surveys carried out by the NBP in selected cities in Poland. Hopefully in the future the results of the Census, efforts of Statistics Poland and an improved system of registration of immigrants in Poland would result in availability of more precise official data. Second, this paper presents a method of accounting for the sources of past growth but does not offer a model that would allow to simulate the reaction of enterprises to changes in the availability of production factors. Further work is still needed to understand how firms would have coped with the problem of a shrinking native labour force in the absence of immigration, for example to what extent automation and robotization of production would have substituted for the labour of immigrants. Another area for potential future extensions of the analysis would be to compare the current immigration effects to the effects of a large wave of emigration from Poland in 2004-08 (Hołda *et al.*, 2011).

In our opinion estimates presented in this study are essential in the discussion about the contemporary drivers of growth in the Polish economy and the ramifications of immigration policy, both in Poland and elsewhere. We find that large-scale immigration from Ukraine was a significant factor behind Poland's dynamic economic growth in the recent years. However, such dynamic inflow of immigrants from Ukraine cannot be sustained much longer. In 2018 for the first time since 2014 the inflow of new immigrants slowed down. For one thing, population aging is visible not only in Poland but also in other countries of our region including Ukraine and the potential for further migration is limited. Improving economic situation in Ukraine – if taking place – should also deter decisions about emigration. Accordingly, increased availability of work in other countries such as Germany may encourage Ukrainian migrants to skip Poland and move further west. Moreover the unstable situation of majority of immigrant workers in Poland (Chmielewska *et al.* (2019)) creates also a risk of their potential outflow if external conditions change.

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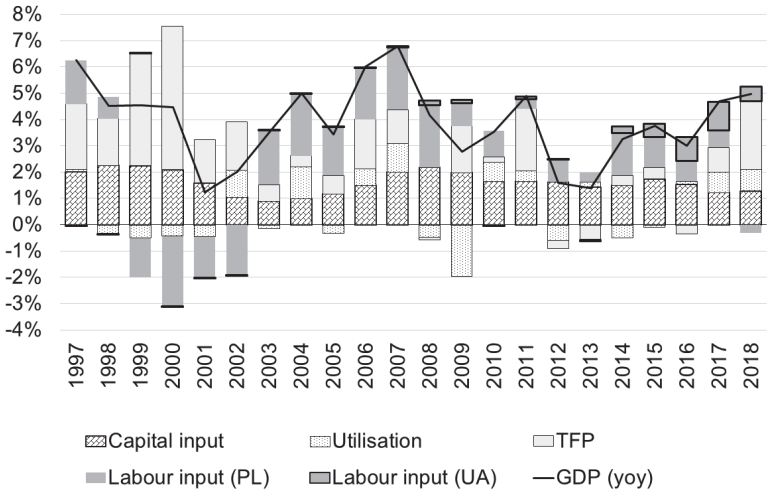
A Appendix

Figure 11: Decomposition of GDP growth including the distinction between contributions of the native (PL) and immigrant (UA) workforce: *alternative* scenario



Source: Own calculations

Table 9: Decomposition of annual growth of the labour input (in %) in the baseline scenario

Year	Total	E(PL)	H(PL)	Q(PL)	E(UA)	H(UA)	Q(UA)
1996	2.3	1.3	0.8	0.3	0.0	0.0	0.0
1997	2.4	1.7	-0.3	1.0	0.0	0.0	0.0
1998	1.2	1.3	-1.1	1.0	0.0	0.0	0.0
1999	-3.0	-2.9	-0.6	0.5	0.0	0.0	0.0
2000	-2.5	-2.4	-0.5	0.5	0.0	0.0	0.0
2001	-2.2	-2.2	-0.9	0.8	0.0	0.0	0.0
2002	-2.7	-3.1	-0.3	0.8	0.0	0.0	0.0
2003	3.2	0.4	0.1	2.6	0.0	0.0	0.0
2004	3.7	1.2	0.1	2.4	0.0	0.0	0.0
2005	3.0	1.6	-0.2	1.5	0.0	0.0	0.0
2006	3.2	2.8	0.0	0.3	0.1	0.0	0.0
2007	3.9	3.8	0.0	0.0	0.1	0.0	0.0
2008	4.1	4.1	-0.4	0.1	0.3	0.1	-0.1
2009	1.6	0.8	-1.0	1.5	0.2	0.0	0.0
2010	1.5	0.4	-0.2	1.3	0.0	0.0	0.0
2011	0.9	1.0	-0.5	0.1	0.3	0.1	-0.1
2012	1.5	0.2	0.0	1.2	0.1	0.0	0.0
2013	0.7	-0.1	-0.2	0.9	0.1	0.0	0.0
2014	3.2	1.9	0.3	0.5	0.5	0.1	-0.1
2015	2.5	1.4	0.2	0.4	0.6	0.2	-0.2
2016	2.5	0.7	0.1	0.4	1.1	0.3	-0.2
2017	2.4	1.4	-1.1	0.8	1.3	0.3	-0.3
2018	0.1	0.4	-1.4	0.5	0.6	0.1	-0.1

Source: Own calculations. E: number of employees; H: hours worked per employee; Q: composition of hours worked. PL: Polish workers, UA: Ukrainian workers.

Table 10: Decomposition of annual GDP growth (in %) in the baseline scenario

Year	GDP (yoy)	Capital input	Labour input (PL)	Labour input (UA)	Utilisation	TFP
1997	6.3	2.0	1.7	0.0	0.1	2.5
1998	4.5	2.3	0.8	0.0	-0.3	1.8
1999	4.5	2.3	-1.5	0.0	-0.5	4.3
2000	4.5	2.1	-2.7	0.0	-0.4	5.5
2001	1.2	1.6	-1.6	0.0	-0.4	1.7
2002	2.0	1.1	-1.9	0.0	1.0	1.9
2003	3.5	0.9	2.1	0.0	-0.1	0.6
2004	5.0	1.0	2.4	0.0	1.2	0.4
2005	3.4	1.2	1.8	0.0	-0.3	0.7
2006	6.0	1.5	1.9	0.0	0.6	1.9
2007	6.8	2.0	2.4	0.1	1.1	1.3
2008	4.2	2.2	2.3	0.2	-0.5	-0.1
2009	2.8	2.0	0.9	0.1	-2.0	1.8
2010	3.5	1.7	1.0	0.0	0.7	0.2
2011	4.9	1.7	0.4	0.2	0.4	2.3
2012	1.6	1.6	0.9	0.0	-0.6	-0.4
2013	1.4	1.4	0.4	0.1	0.2	-0.7
2014	3.3	1.5	1.6	0.3	-0.5	0.3
2015	3.8	1.7	1.1	0.3	-0.1	0.6
2016	3.0	1.5	0.8	0.7	0.1	-0.1
2017	4.7	1.2	0.7	0.8	0.8	1.2
2018	5.0	1.3	-0.3	0.3	0.8	2.8

Source: Own calculations

Table 11: Comparison of contributions of the labour input of immigrants to annual GDP growth (in %) in different scenarios

Year	Baseline	Alternative scenario	Baseline −20%	Baseline +20%	Like PL
1997	0.0	0.0	0.0	0.0	0.0
1998	0.0	0.0	0.0	0.0	0.0
1999	0.0	0.0	0.0	0.0	0.0
2000	0.0	0.0	0.0	0.0	0.0
2001	0.0	0.0	0.0	0.0	0.0
2002	0.0	0.0	0.0	0.0	0.0
2003	0.0	0.0	0.0	0.0	0.0
2004	0.0	0.0	0.0	0.0	0.0
2005	0.0	0.0	0.0	0.0	0.0
2006	0.0	0.0	0.0	0.0	0.0
2007	0.1	0.1	0.0	0.1	0.0
2008	0.2	0.2	0.1	0.2	0.2
2009	0.1	0.1	0.1	0.1	0.1
2010	0.0	0.0	0.0	0.0	0.0
2011	0.2	0.1	0.2	0.3	0.2
2012	0.0	0.0	0.0	0.1	0.1
2013	0.1	0.0	0.0	0.1	0.1
2014	0.3	0.2	0.2	0.4	0.3
2015	0.3	0.5	0.3	0.4	0.3
2016	0.7	0.9	0.6	0.8	0.7
2017	0.8	1.1	0.6	0.9	0.8
2018	0.3	0.6	0.0	0.4	0.3

Source: Own calculations. Like PL: scenario assuming that all characteristics of immigrants are the same as the characteristics of natives, and the number of immigrants is the same as in the baseline.

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