

An estimation of the contribution of the foreign population in Spain to GDP per capita growth in the period 2022-2024

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Rationale

Migratory flows to Spain have been particularly strong following the pandemic, contributing to the growth of GDP and employment in the Spanish economy. This article estimates the contribution of the foreign population to GDP per capita growth in Spain between 2022 and 2024 and quantifies the channels through which it was made.

Takeaways

- GDP per capita in Spain grew at an annual average rate of 2.9% between 2022 and 2024.
- Based on a mechanical decomposition, the foreign population made an average direct contribution to GDP per capita growth of between 0.4 percentage points (pp) and 0.7 pp.
- This contribution is similar, in relative terms, to that estimated in prior upswings and was mainly shaped by two factors: the headway in the assimilation – in different dimensions – of the immigrants who entered Spain in the early 2000s and the improvements in the education level and the occupational distribution of those who have arrived in recent years.

Keywords

Immigration, GDP per capita, productivity, employment, population.

JEL classification

F22, J23, J24, J31, J61.

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Introduction

The recovery in migratory flows after the pandemic has positioned Spain as one of the main recipients of immigrants in the European Union (Cuadrado, Gómez and Sastre, 2024). Migratory flows also increased Spain's resident population by more than 1.5 million people between end-2020 and 2024 Q4, according to the Spanish Labour Force Survey (EPA by its Spanish initials), despite the fall in the native population.

This recent influx of foreigners has joined those who already resided here, having migrated to Spain in the early 2000s. In this respect, it is worth clarifying that there are two basic criteria for defining the foreign population: citizenship and country of birth. At end-2024, while foreign nationals numbered around 6.7 million (13.8% of the total), the foreign-born amounted to almost 9 million (18.4%), according to the EPA.¹

The size of this group (irrespective of the criterion used to define them) highlights the importance of studying the potential economic effects of immigration on different facets of the Spanish economy, such as the public finances, productivity and potential growth. With this in mind, this article estimates the direct contribution of the foreign population to GDP per capita growth since the pandemic; specifically, between 2022 and 2024.²

Given that the size of the foreign population differs considerably depending on the criterion used (citizenship or country of birth), the main findings of this article are presented for both. Meanwhile, there are several ways to define the working age population. In this article we have chosen the population aged 16 to 67, due to the gradual increase in the statutory retirement age, which will be 67 in 2027.³ This has resulted in a rise in the participation and employment rates of the over-64s.

The rest of this article is structured as follows. The second section decomposes GDP per capita growth into the following factors: the working age population as a proportion of the total population, employment rate, hours worked per person employed and productivity per hour worked.⁴ The third section summarises the main characteristics of Spain's resident foreign population and how

1 The differences between the two population groups are due to the processes to obtain Spanish citizenship. In 2023 almost 250,000 foreigners obtained Spanish citizenship.

2 The health crisis triggered a sharp drop in GDP per capita in 2020 (12%), which subsequently rose by 6.4% in 2021. We opted to exclude these two years from the analysis in this article because of the extraordinary nature of these dynamics.

3 However, we also performed the exercise for other age brackets, such as 16-64 and the over-16s. This definition does not change the overall direct effect of the foreign population, but it does impact the channels through which it arises. In any event, any significant differences depending on the age bracket considered are discussed in the text.

4 Methodologically, the analysis replicates the exercise presented in Table 2.1 of the *Annual Report 2006* (Banco de España, 2007, pp. 40). The only change is productivity per person employed being broken down into productivity per hour worked and hours worked per person employed.

it has changed in recent years. Lastly, the fourth section estimates the component attributable to this population group for each of the factors into which GDP per capita growth is decomposed in the second section, before calculating the overall contribution of immigration to GDP per capita growth as the sum of those factors.

For all calculations we use the national accounts (NA) time series for real GDP, population and employment (persons employed and hours worked), which are supplemented with information from the EPA from 2005 onwards. Similarly, when decomposing productivity into nationals and foreigners, given the lack of direct information on this variable, we use wage income information from the microdata in the Structure of Earnings Survey (SES).⁵

Decomposition of GDP per capita growth

This section presents the results of decomposing GDP per capita into the product of four factors: the working age population as a proportion of the total population (demographic factor), the employment rate, hours worked per person employed (average working hours) and productivity per hour worked. The decomposition of GDP per capita can be expressed as follows, where N refers to the total population, N_{1667} to the working age population, H to total hours worked and L to total employment:

$$\frac{GDP}{N} = \frac{GDP}{H} \frac{H}{L} \frac{L}{N_{1667}} \frac{N_{1667}}{N}$$

Therefore, the GDP per capita growth rate can be approximated⁶ by the sum of the rates of change of these four components. The results of this decomposition are presented in the highlighted columns of Table 1. In prior upswings, such as 2006-2007 (the end of the real estate boom) and 2014-2019 (the post-financial crisis recovery), the employment rate was the main factor behind GDP per capita growth. By contrast, productivity (calculated as the sum of the contribution of productivity per hour worked and the number of hours worked per person employed) made a very small contribution, like the demographic factor, against a backdrop of population ageing.

More recently, in the period 2022-2024, the average annual GDP per capita growth rate (2.9%) was somewhat higher than that recorded in prior upswings. As in the past, GDP per capita growth was mainly underpinned by the buoyancy of the employment rate. Yet, compared with prior episodes, the contribution of productivity per hour worked and the demographic factor is now larger.

⁵ We use the 2006, 2010, 2014, 2018 and 2022 waves of the SES. In the years between waves, wages are extrapolated linearly and from 2022 onwards we assume that the wage differential between nationals and foreigners by sector remains constant. Note that, unlike the EPA, the SES only considers lawfully resident foreigners.

⁶ In particular, the GDP per capita growth rate is approximated by the difference of the logarithms of such variable, such that it can be decomposed as the sum of the differences of the logarithms of the above-mentioned components.

Table 1

Decomposition of GDP per capita growth in the Spanish economy and the effect of immigration

Citizenship criterion										
GDP per capita		Demographic factor (a)		Employment rate (a)		Working hours		Productivity per hour (b)		
Annual average change (%)	Impact of immigration (pp)	Annual average change (%)	Impact of immigration (pp)	Annual average change (%)	Impact of immigration (pp)	Annual average change (%)	Impact of immigration (pp)	Annual average change (%)	Impact of immigration (pp)	
2006-2007	1.9	0.2	0.0	0.2	1.8	0.1	-0.7	0.0	0.8	-0.1
2008-2013	-1.8	-0.9	-0.3	-0.1	-3.0	-0.7	-0.1	-0.2	1.6	0.0
2014-2019	2.4	0.2	-0.2	0.0	2.2	0.4	-0.1	0.1	0.5	-0.2
2022-2024	2.9	0.4	0.2	0.1	1.6	0.3	0.0	0.1	1.1	-0.1

Country of birth criterion										
GDP per capita		Demographic factor (a)		Employment rate (a)		Working hours		Productivity per hour (b)		
Annual average change (%)	Impact of immigration (pp)	Annual average change (%)	Impact of immigration (pp)	Annual average change (%)	Impact of immigration (pp)	Annual average change (%)	Impact of immigration (pp)	Annual average change (%)	Impact of immigration (pp)	
2006-2007	1.9	0.4	0.0	0.3	1.8	0.2	-0.7	0.0	0.8	-0.1
2008-2013	-1.8	-0.9	-0.3	0.1	-3.0	-0.8	-0.1	-0.2	1.6	0.0
2014-2019	2.4	0.5	-0.2	0.1	2.2	0.5	-0.1	0.1	0.5	-0.1
2022-2024	2.9	0.7	0.2	0.2	1.6	0.5	0.0	0.1	1.1	-0.2

SOURCES: INE and Banco de España.

a The working-age population is those aged 16-67.

b The productivity factor is broken down according to the differential between the median wages of nationals and foreigners.

Changes in the characteristics of the foreign population compared with nationals in recent years

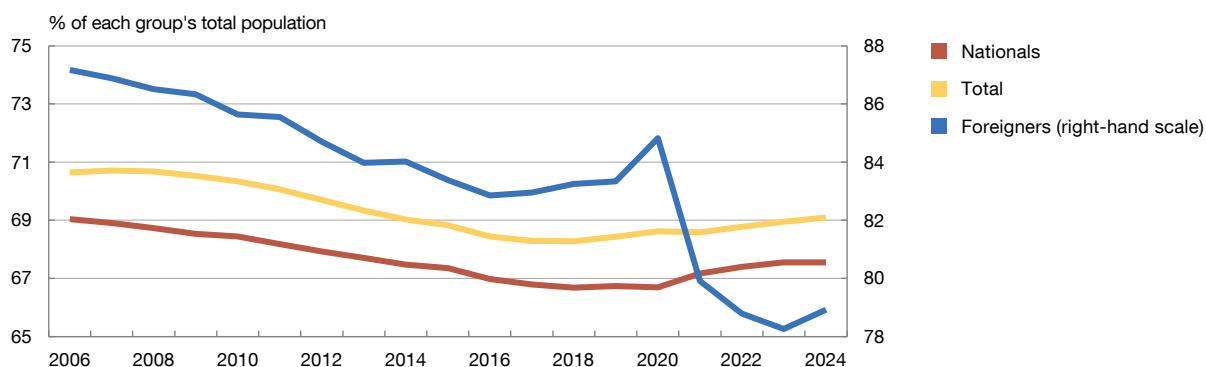
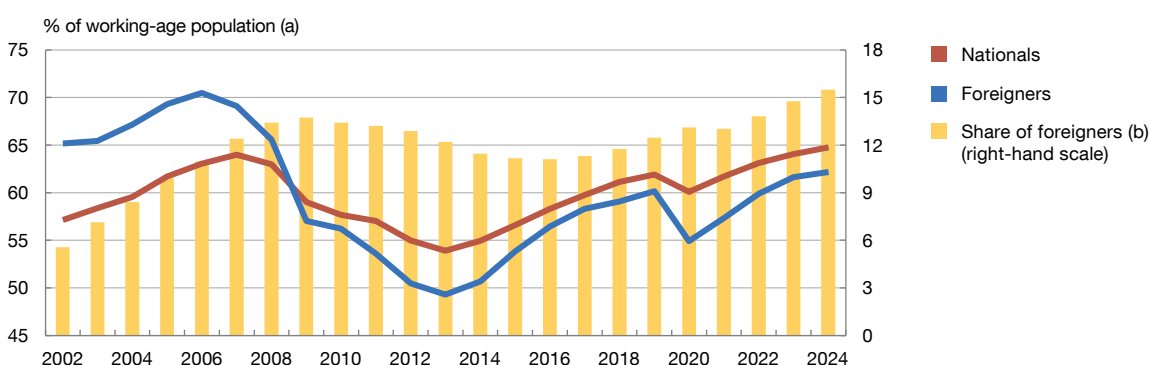
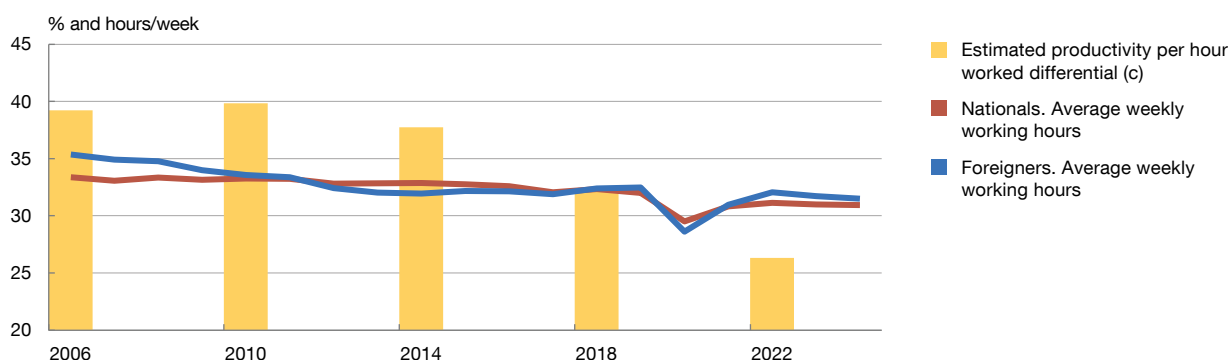
Before estimating the contributions of the foreign population to the different components of GDP per capita, it is interesting to analyse how their characteristics have changed vis-à-vis those of the national population in recent years. First, working age (16-67) foreigners continue to account for a higher proportion of the total foreign population than working age nationals do of the national population, although it has gradually decreased as the immigrants that arrived in the early 2000s – in relatively high numbers – have aged (see Chart 1.a).⁷ Chart 1.a also shows that since 2021 there has been a slight increase in working age natives as a proportion of the total national population, interrupting the prior downward trend.⁸

In the early 2000s the employment rate among foreigners reached over 70%, compared with 62.2% in 2024. But unlike in the early 2000s, since 2009 such rate has been lower than that for

⁷ Chart 1 depicts the breakdown between foreigners and nationals by citizenship only. The results are largely similar for the country of birth breakdown. Where this is not the case, it is discussed in the article.

⁸ There is barely any increase if we consider the working age to be 16-64. Therefore, it could be due to the first generations of baby boomers reaching 65 to 67 years of age.

Chart 1

Nationals and foreigners in Spain: population, employment and productivity**1.a Working age population. Nationals and foreigners (a) (b)****1.b Employment rate. Nationals and foreigners****1.c Estimated productivity differential between nationals and foreigners, and average working hours of both population groups (b)**

SOURCES: INE and Banco de España.

a The working-age population is those aged 16-67.

b Foreigners means those without Spanish citizenship (excluding those with dual citizenship).

c Hourly wage differential in the SES between nationals and foreigners by sector of activity, weighted by hours worked. For the sectors and years where this information is unavailable (such as agriculture and domestic help, for the entire period, and public administration, before 2006), we use the aggregate median wage in each year.



nationals (see Chart 1.b). This change of sign in the employment rate differential is attributable to the sharp rise in unemployment among the immigrant population at the onset of the financial crisis, which has remained above unemployment among nationals since then. This is despite the faster pace of growth of employment among foreigners recorded in upswings, like in the recent period: in 2024, for example, the number of foreigners in employment grew by 6.9%, compared with growth of 1.4% among nationals.⁹

Turning to the participation rate, when considering the population aged 16-67, the rate is higher among foreigners than nationals.¹⁰ However, foreigners' participation rates have been decreasing since 2010, reducing the differential with the rates for nationals. Indeed, if we consider the working age population to be only those aged 16-64 and we adopt the citizenship criterion, the participation rate among foreigners in 2024 matched that of the nationals.¹¹

With regard to average working hours, in 2006 foreigners worked almost two hours a week more than nationals (see Chart 1.c). The gap turned negative during a large part of the financial crisis and at the beginning of the subsequent upswing, until 2022, when it became positive again, albeit only very marginally (in 2024 the difference was less than half an hour a week). This is because of the shorter relative working week of foreigners who work part-time, in a setting where there continues to be a positive differential between the full-time working hours of foreigners and nationals.

Lastly, according to the SES the hourly wage differential between nationals and foreigners has narrowed in recent years.¹² Assuming that the productivity per hour worked differential between nationals and foreigners approximates to the hourly wage differential, foreigners' productivity has been catching up with that of the nationals (see Chart 1.c). This result is consistent with the assimilation of the waves of immigrants who arrived in the early 2000s, with the higher education level of the foreigners who have arrived in recent years¹³ and with immigrants shifting slightly to activities requiring a higher level of qualification, which are typically more productive (Cuadrado, Gómez and Sastre, 2024).

Generally speaking, it should be noted that recent developments in all these indicators are increasingly influenced by the employment status of the foreign population that has been in Spain the longest, since this group is very large (in 2024 75% of foreigners had resided in Spain for at least four years).

9 Using the country of birth criterion, the differential between foreigners and natives is slightly bigger (with employment growing by 8% and 0.7%, respectively).

10 Under the citizenship criterion, the differential is around 2.5 pp between 2022 and 2024, while by country of birth it is around 5.5 pp.

11 If we use the country of birth criterion, by contrast, the differential between the participation rates for the 16-64s has been around 3 pp since 2020.

12 Calculated drawing on the median wage of each group by activity (at section level), weighted by hours worked, according to the NA. To calculate the breakdown of hours worked between nationals and foreigners, we use the hours actually worked by each group and activity (at section level) from the EPA.

13 The percentage of immigrants to Spain with a low level of education fell by an estimated 15 pp between 2008 and 2022 (from 45% to 30%) and that of those with a high education level rose by more than 20 pp (from 20% to 43%) (Cuadrado, Gómez and Sastre, 2024).

Contribution of the foreign population to GDP per capita

The growth in each determinant of GDP per capita can be decomposed into the part attributable to nationals and the part associated with the foreign population. This breakdown is mechanical and does not consider potential indirect effects between the two groups, which would require a more complex economic model. While plausible, at least in the short term, this assumption advises interpreting the results with caution. In this respect, the available empirical evidence for Spain suggests that immigration has no significant negative effects on employment opportunities or wages for native workers overall (Carrasco, 2024; Carrasco and Ortega, 2006).

For all factors except for productivity per hour worked, the contributions of Spanish and foreign nationals are calculated using analytical equations that take into account the appropriately weighted rates of change in the numerator and denominator of each factor for each group.¹⁴ This calculation relies on statistical information from the EPA that allows each of the variables to be broken down into the national and foreign population segments.

As for productivity, the breakdown between Spanish and foreign nationals is particularly complex, as direct information on each worker's individual performance is not available. In the economy as a whole, given that immigrants tend to hold more jobs in sectors where productivity is below average, an increase in foreign labour tends to have a negative composition effect on aggregate productivity.¹⁵ This impact may be mitigated or exacerbated depending on how the productivity per hour worked differential between natives and immigrants within these sectors changes. As mentioned above, in practical terms the productivity per hour worked differential between nationals and foreigners is proxied by the wage differential between the two groups, by sector (at section level), according to the SES.¹⁶

Thus, the total contribution of the foreign population to GDP per capita growth in Spain between 2022 and 2024, calculated as the sum of the four factors indicated above, is estimated at 0.4 pp based on the citizenship criterion and 0.7 pp based on the country of birth criterion (see Table 1). There is no significant change in these results if different age brackets are used for the working age population.

As regards the channels through which foreigners contributed to GDP per capita growth between 2022 and 2024, the most relevant is the employment rate, which accounts for a large part of the total effect. There was also a positive contribution through the demographic factor, albeit more modest than through the employment rate. Foreigners also made a small positive contribution

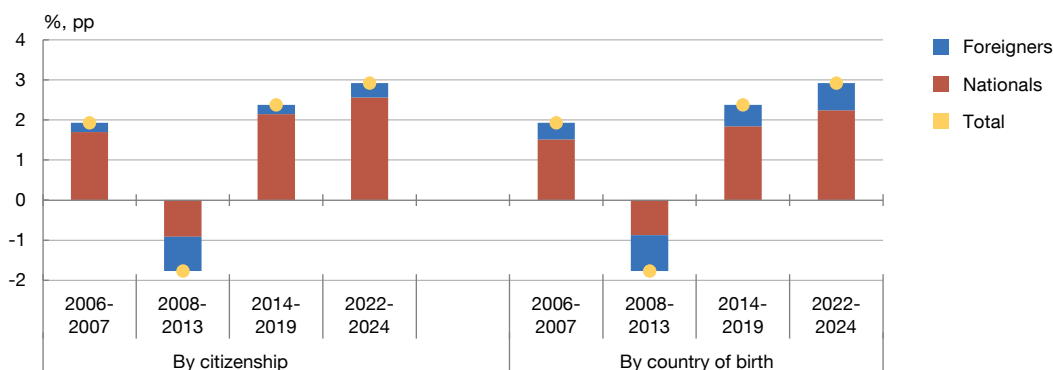
14 See the appendix included at the end of the article, which lists the above-mentioned analytical equations.

15 For example, almost 35% of foreigners had jobs in the hospitality, construction and domestic help sectors (whose hourly value added is lower than other sectors'), compared with only 13.2% of Spanish natives.

16 Specifically, as explained above, the median hourly wage is used broken down at section level of the Spanish National Classification of Economic Activities (equal to the NACE Rev. 2) and appropriately weighted. The results are very similar when the average is used instead of the median. Furthermore, as the SES does not cover the agriculture or domestic help sectors, it is assumed that the differential in these sectors is equal to the average differential for the other sectors. Similarly, the SES provides a breakdown by citizenship, but not by country of birth. To analyse the foreign-born population, it is assumed that their productivity differential with the native-born population is equal to that estimated for foreign nationals.

Chart 2
GDP per capita in Spain

2.a GDP per capita in Spain and contributions of nationals and foreigners



SOURCES: INE and Banco de España.



since the end of the financial crisis through the working hours factor. By contrast, their contribution to GDP per capita growth through their influence on hourly productivity developments was negative, as in previous expansionary periods.

It should be noted that, relative to the GDP per capita growth observed at each point in time, these contributions are similar to those estimated for other previous expansionary episodes (see Chart 2 in this article and Table 2.1 in Banco de España, 2007). In any event, as already noted, the results of this mechanical decomposition of GDP per capita growth into its main factors should be interpreted with due caution.

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APPENDIX

Formulae

In general, the rate of change of a ratio whose denominator and numerator can be divided into two addends can be calculated using equation (1), based on equations (a) to (d) below:

$$z_t = \frac{x_t}{y_t} \quad (a)$$

$$x_t = x_t^1 + x_t^2 \quad (b)$$

$$y_t = y_t^1 + y_t^2 \quad (c)$$

The rate of change of any variable between t-1 and t (for example, w_t) is calculated as follows, where tv means rate of change:

$$tv(w_t) = \frac{w_t}{w_{t-1}} - 1 \quad (d)$$

It can then be shown that the ratio's rate of change can be calculated using the following equation:

$$tv(z_t) = \frac{1}{1 + tv(y_t)} * \left[\frac{x_{t-1}^1}{x_{t-1}} tv(x_t^1) - \frac{y_{t-1}^1}{y_{t-1}} tv(y_t^1) \right] + \frac{1}{1 + tv(y_t)} * \left[\frac{x_{t-1}^2}{x_{t-1}} tv(x_t^2) - \frac{y_{t-1}^2}{y_{t-1}} tv(y_t^2) \right] \quad (1)$$

Equation (1) can be used to decompose the demographic, employment rate and working hours factors into the contribution of Spanish nationals and that of foreign nationals. Specifically:

Demographic factor

Definitions:

Demographic factor:

$$FD_t = \frac{P_{1667,t}}{P_t} \quad (d1)$$

Where P is the total population and P_{1667} is the population aged 16-67. These two variables can be broken down by citizenship, with superscript e denoting foreigners and n denoting Spanish nationals.

$$P_t = P_t^e + P_t^n \quad (d2)$$

$$P_{1667,t} = P_{1667,t}^e + P_{1667,t}^n \quad (d3)$$

The rate of change of the demographic factor can then be decomposed as follows:

$$\begin{aligned}
 tv(FD_t) = & \underbrace{\frac{1}{1 + tv(P_t)} * \left[\frac{P_{1667,t-1}^e}{P_{1667,t-1}} tv(P_{1667,t}^e) - \frac{P_{t-1}^e}{P_{t-1}} tv(P_t^e) \right]}_{\text{Foreigners' contribution}} + \\
 & + \underbrace{\frac{1}{1 + tv(P_t)} * \left[\frac{P_{1667,t-1}^n}{P_{1667,t-1}} tv(P_{1667,t}^n) - \frac{P_{t-1}^n}{P_{t-1}} tv(P_t^n) \right]}_{\text{Nationals' contribution}}
 \end{aligned} \tag{r1}$$

Lastly, the rate of change in the demographic factor is approximated by the logarithmic rate: $tv(FD_t) \sim \ln\left(\frac{FD_t}{FD_{t-1}}\right)$, the contribution of the foreign population to the rate of change of the demographic factor is calculated as the first addend of equation (r1), and the remainder is considered to be the contribution of nationals.

Employment factor

Definitions:

Employment factor:

$$TE_t = \frac{E_t}{P_{1667,t}} \tag{d4}$$

Where E is total employment and P_{1667} is the population aged between 16 and 67. These two variables can again be broken down by citizenship, with superscript e denoting foreigners and n denoting Spanish nationals.

$$P_{1667,t} = P_{1667,t}^e + P_{1667,t}^n \tag{d3}$$

$$E_t = E_t^e + E_t^n \tag{d5}$$

The rate of change of the employment factor can then be decomposed as follows:

$$\begin{aligned}
 tv(TE_t) = & \underbrace{\frac{1}{1 + tv(P_{1667,t})} * \left[\frac{E_{t-1}^e}{E_{t-1}} tv(E_t^e) - \frac{P_{1667,t-1}^e}{P_{1667,t-1}} tv(P_{1667,t}^e) \right]}_{\text{Foreigners' contribution}} + \\
 & + \underbrace{\frac{1}{1 + tv(P_{1667,t})} * \left[\frac{E_{t-1}^n}{E_{t-1}} tv(E_t^n) - \frac{P_{1667,t-1}^n}{P_{1667,t-1}} tv(P_{1667,t}^n) \right]}_{\text{Nationals' contribution}}
 \end{aligned} \tag{r2}$$

Again, the rate of change in the employment factor is proxied by the logarithmic rate: $tv(TE_t) \sim \ln\left(\frac{TE_t}{TE_{t-1}}\right)$, the contribution of the foreign population is calculated as the first addend of equation (r2), and the remainder is considered to be the contribution of nationals.

Working hours factor

Definitions:

Working hours factor (average working hours):

$$JM_t = \frac{H_t}{E_t} \quad (d6)$$

Where H represents hours worked and E is employment. These two variables can again be broken down by citizenship, with superscript e denoting foreigners and n denoting Spanish nationals.

$$E_t = E_t^e + E_t^n \quad (d5)$$

$$H_t = H_t^e + H_t^n \quad (d7)$$

The rate of change of the working hours factor (JM) can then be decomposed as follows:

$$tv(JM_t) = \underbrace{\frac{1}{1 + tv(E_t)} * \left[\frac{H_{t-1}^e}{H_{t-1}} tv(H_t^e) - \frac{E_{t-1}^e}{E_{t-1}} tv(E_t^e) \right]}_{\text{Foreigners' contribution}} + \underbrace{\frac{1}{1 + tv(E_t)} * \left[\frac{H_{t-1}^n}{H_{t-1}} tv(H_t^n) - \frac{E_{t-1}^n}{E_{t-1}} tv(E_t^n) \right]}_{\text{Nationals' contribution}} \quad (r3)$$

Again, the rate of change in the working hours factor is proxied by the logarithmic rate: $tv(JM_t) \sim \ln\left(\frac{JM_t}{JM_{t-1}}\right)$, the contribution of the foreign population is calculated as the first addend of equation (r3), and the remainder is considered to be the contribution of Spanish nationals.

Productivity factor

Definitions:

Productivity per hours worked:

$$PH_t = \frac{GDP_t}{H_t} \quad (d8)$$

Where GDP is measured in real terms (in 2015 euro) and H is the number of hours worked.

Productivity of each sector s, as a function of GVA: $x_t^s = \frac{GVA_t^s}{H_t^s}$, where GVA is the real value added (in monetised terms in 2015 euro, like GDP) of sector s in year t. (d9)

Foreigners' productivity in sector s: $x_t^{e,s} = \frac{\widetilde{GVA}_t^{e,s}}{H_t^{e,s}}$ (d10)

Nationals' productivity in sector s: $x_t^{n,s} = \frac{\widetilde{GVA}_t^{n,s}}{H_t^{n,s}}$ (d10')

$\widetilde{GVA}_t^{e,s}$ refers to the (unobservable) real GVA generated by foreign workers and $\widetilde{GVA}_t^{n,s}$ to that of nationals, such that: $GVA_t^s = \widetilde{GVA}_t^{e,s} + \widetilde{GVA}_t^{n,s}$.

Within each sector s: (d11) $\alpha_t^s = \frac{H_t^{e,s}}{H_t^s}$ represents the share of employment (measured in hours) in sector s in year t accounted for by foreigners and (d12) $\gamma_t^s = \frac{H_t^s}{H_t}$ represents the share of total employment (measured in hours) in year t accounted for by sector s.

Foreigners' apparent productivity per hour, relative to that of Spanish nationals, is then assumed to be equal to the (median) hourly wage differential between these groups, in each sector of activity. In other words:

For each sector s:

$$\frac{x_t^{e,s}}{x_t^{n,s}} = \frac{w_t^{e,s}}{w_t^{n,s}} = 1 - \delta_t^s \quad (S1)$$

Using (S1) it can be shown that:

$$\begin{aligned} x_t^s &= \frac{\widetilde{GVA}_t^{e,s} + \widetilde{GVA}_t^{n,s}}{H_t^{e,s} + H_t^{n,s}} = \frac{\widetilde{GVA}_t^{e,s}}{H_t^{e,s}} * \frac{H_t^{e,s}}{H_t^{e,s} + H_t^{n,s}} + \frac{\widetilde{GVA}_t^{n,s}}{H_t^{n,s}} * \frac{H_t^{n,s}}{H_t^{e,s} + H_t^{n,s}} = x_t^{e,s} * \alpha_t^s + x_t^{n,s} * (1 - \alpha_t^s) \\ &= x_t^{n,s} * (1 - \delta_t^s * \alpha_t^s) \end{aligned} \quad (r4)$$

For aggregate productivity, x_t , using (r4) the following equation is obtained:

$$x_t = \frac{GVA_t}{H_t} \Rightarrow x_t = \frac{\sum_s GVA_t^s}{\sum_s H_t^s} = \sum_s \gamma_t^s * x_t^s = \sum_s \gamma_t^s * x_t^{n,s} * (1 - \delta_t^s * \alpha_t^s) = x_t \quad (r5)$$

Taking differences Δ_t in (r5), the following is obtained:

$$\Delta x_t = \sum_s \Delta \gamma_t^s * x_t^{n,s} * (1 - \delta_t^s * \alpha_t^s) + \sum_s \gamma_{t-1}^s * \Delta x_t^{n,s} * (1 - \delta_t^s * \alpha_t^s) + \sum_s \gamma_{t-1}^s * x_{t-1}^{n,s} * \Delta(1 - \delta_t^s * \alpha_t^s) \quad (r6)$$

The decomposition of the rate of change in apparent labour productivity (measured in hours worked) in terms of GVA is obtained by dividing the above equation by productivity in $t-1$.

$$\begin{aligned} tv(x_t) = & \underbrace{\left[\sum_s \Delta \gamma_t^s * x_t^{n,s} * (1 - \delta_t^s * \alpha_t^s) \right] / x_{t-1}}_{\text{Composition effect}} + \underbrace{\left[\sum_s \gamma_{t-1}^s * \Delta x_t^{n,s} * (1 - \delta_t^s * \alpha_t^s) \right] / x_{t-1}}_{\text{Changes in productivity}} + \\ & + \underbrace{\left[\sum_s \gamma_{t-1}^s * x_{t-1}^{n,s} * \Delta(1 - \delta_t^s * \alpha_t^s) \right] / x_{t-1}}_{\text{Effect of foreigners on changes in the productivity of nationals and foreigners}} \end{aligned} \quad (r7)$$

The third addend of (r7) is deemed to be the contribution of foreigners to the rate of change in hourly GVA productivity:

$$Cl_{GVA,t} = \frac{\sum_s \gamma_{t-1}^s * x_{t-1}^{n,s} * \Delta(1 - \delta_t^s * \alpha_t^s)}{x_{t-1}} \quad (r8)$$

This estimation of the foreign population's contribution allows productivity to change due to composition effects (whereby aggregate productivity increases when the share of GVA accounted for by a sector with higher productivity increases) and to actual improvements in productivity in the various sectors.

Finally, an additional assumption needs to be made in order to calculate the contribution of foreigners to apparent productivity in terms of GDP. Given the close link between the rates of change of GDP and GVA (both in real terms), in order to obtain the contribution of foreigners to apparent labour productivity in terms of GDP (per hour worked), their contribution to the rate of change in apparent labour productivity in terms of GVA (per hour) is assumed to be equal in relative terms to their contribution to productivity in terms of GDP. The contribution of foreigners to the rate of change of apparent labour productivity in terms of GVA per hour worked is dubbed $Cl_{GVA,t}$, which is calculated as (r8), and the contribution of foreigners to the rate of change of apparent labour productivity in terms of GDP per hour worked is dubbed $Cl_{GDP,t}$.

Therefore, it is assumed that:

$$Cl_{GVA,t} / \frac{\Delta GVA_t}{GVA_{t-1}} = Cl_{GDP,t} / \frac{\Delta GDP_t}{GDP_{t-1}} \quad (S2)$$

Lastly, the contribution of foreigners to apparent labour productivity (per hour) in terms of GDP is estimated as:

$$Cl_{GDP,t} = \frac{\sum_s \gamma_{t-1}^s * x_{t-1}^{n,s} * \Delta(1 - \delta_t^s * \alpha_t^s)}{\Delta x_t} * \left(\frac{\Delta GVA_t}{GVA_{t-1}} / \frac{\Delta GDP_t}{GDP_{t-1}} \right) \quad (r9)$$

(It should be remembered that: $x_t = \frac{GVA_t}{H_t}$).

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