FORECASTING ADULT SKILLS IN SLOVAKIA: METHODOLOGICAL ISSUES RELATED TO THE UPCOMING PIAAC SURVEY

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Abstract

In the current decade, the challenges in the sustainability of public finances associated with an aging population and the environment will be reflected in significant changes in the labor market. Knowing the determinants of labor supply and demand can be of great help in decisions towards the institutional reforms in education that can help close the gap between demand and supply through timely action. Given the global trends of digitization and automation, the quality of human capital is derived from the cognitive abilities of employees. Their measurement in the PIAAC project (OECD) is methodologically compatible with testing students using PISA in the areas of numeracy and literacy. PIAAC projections for 2030 use PISA results as a determinant of cognitive abilities in later life. The declining trend in PISA results determines the deterioration of PIAAC performance across age categories and shifts the focus of the population's cognitive skills towards higher age groups. The forthcoming PIAAC 2022 testing has the potential to better identify trends, compare cohorts over time, and refine forecasts.

Keywords

PIAAC determinants, PISA trend, adult skills projection

I. Introduction

Structural changes in the labor market are becoming increasingly dynamic. From this point of view, labor market forecasts are a welcome basis for economic policy decisions. The right decisions and their implementation can realize the opportunities that restructuring offers in the form of the development of new areas of economic life. Adapting to future needs is the basis for minimizing the economic and social consequences of the transition.

The Slovak labor market is already facing several challenges arising from the imbalance between supply and demand. A long-term trend on the demand side is the substitution of labor by capital associated with digitization and automation across sectors of the national economy. These changes bring demands for the flexibility of the workforce in terms of qualifications and forms of work performance. The importance of lifelong learning and non-specific cognitive skills is growing in jobs with a smaller share of automation activities.

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Knowledge of possible labor market conditions, both in terms of quantity and quality, is indispensable for policy-making. From the empirical analyzes of the Slovak labor market, it can be stated that future challenges will, in addition to global trends, specifically determine the following tendencies in particular:

• horizontal mismatch
• vertical mismatch
• aging factor
• youth skills trends.

Analytical forecasting tools include a range of quantitative methods. The adequacy of their use depends on the complexity of the forecasted indicators, the forecast horizon and the statistical characteristics of the available data. There is a bulk of methods for measuring the quality of human capital. In predicting medium-term employment, naïve methods such as ARIMA tailored to short-term forecasts are overperformed by structural modelling. In macroeconomic models used for strategic economic policy-making, the quality of human capital is often approximated not only by the average years of schooling, but also by the actual skills applicable in economic activities. The most comprehensive approach to measuring labor quality is the cognitive testing for youth (PISA) and adults (PIAAC).

On the demand side of labor, forecasts of the development of qualifications and employment of workers use a complex of relations in the field of economic development. The future needs of individual industries are based on historical data and relationships described by behavioral equations in the structural model. For the sustainability of modeling assumptions - stability of trends or parameter values, the limit is the ten-year forecast horizon. According to the demographic projections (Bleha et al., 2013), the year 2030 is a point when and significant changes in the assumptions used can be expected under the most optimistic scenario where the total population of Slovakia starts to decrease.

II. Cognitive skills and their determinants

The level of cognitive skills achieved and the educational structure of the workforce are often used predictors in economic growth analyzes, where they act as measures of human capital accumulation at the aggregate level. Embedded in accumulated human capital, higher cognitive skills offer a path of sustained economic improvement, so that favorable policies today have growing impacts in the future. However, over the course of an individual's life, the level of cognitive abilities is influenced by several, often conflicting factors, which contribute to the distribution of these abilities across age groups.

Cognitive abilities in the population are measured using the OECD methodology in the PIAAC project. Developed and organized by the OECD, Program for the International Assessment of Adult Competencies (PIAAC) is a cyclical multidimensional assessment of adults´ skills in three domains:

- Literacy (LIT) – defined as "*understanding, evaluating, using and engaging with written text to participate in society, to achieve one's goals and to develop one's knowledge and potential"* (OECD, 2012)
- Numeracy (NUM) – assesses basic math and computational skills considered fundamental for operating in everyday life: work as well as social interactions.
- Reading components (RC) concentrates on elements of reading: reading vocabulary, sentence comprehension, and basic passage comprehension. Comparability across the range of languages in the participating countries is ensured. Designed to provide information about the literacy at the lower end of the L spectrum.
- Problem solving (PS) in technology-rich environments – defined as "*using digital technology, communication tools, and networks to acquire and evaluate information, communicate with others, and perform practical tasks.*" (OECD, 2012)

In PIAAC evaluation, matrix-sampling is employed, i.e. each participant is only presented with a subset of the full set of items. For the final result, ten so called plausible values are estimated, together including information about both the level and the uncertainty of an individual's score.

Table 1: PIAAC results by age group (Slovakia)

Age group	LIT		NUM		PS	
	score	*SE*	*score*	*SE*	*score*	*SE*
16-65	**274**	**(0,6)**	**276**	**(0,8)**	**281**	**(0,8)**
16-19	273	(2,4)	276	(2,9)	287	(2,1)
20-24	278	(2,0)	280	(2,2)	286	(2,3)
25-29	279	(2,1)	280	(2,3)	284	(2,8)
30-34	278	(2,1)	278	(2,4)	285	(2,4)
35-39	282	(1,9)	284	(2,1)	280	(2,8)
40-44	273	(2,3)	278	(2,6)	278	(2,6)
45-49	273	(1,8)	280	(2,1)	277	(2,5)
50-54	267	(2,2)	270	(2,5)	272	(3,9)
55-59	265	(1,9)	267	(2,4)	269	(3,1)
60-65	267	(1,7)	264	(2,1)	275	(3,8)

Zdroj: OECD PIAAC Data Explorer

In Table 1, final score along with estimated standard errors are exhibited. One could notice that cognitive abilities typically peak after 30 years of life. However, the rate of decline in these abilities

at a later age is different for the three areas tested. Differences between age groups exceed the standard error of estimates (SE). This heterogeneity must be taken into account when predicting cognitive abilities. The specific structure of the measured indicators is about

- time effect
- cohort effect
- age effect

Those three cannot be reliably separated in the absence of panel data. A certain starting point for this problem is the procedure that uses the determinants of the performance of a representative individual in the PIAAC. In pursuit of predicting future skills, the key determinants should be established. In a multitude of cognitive skills studies, a positive association between PIAAC and PISA test results is exploited. PISA (Programme for International Student Assessment) surveys provide comparative data on 15-year-olds' performance in reading, mathematics, and science. Although the goals of each program and the kinds of analytic questions that each has been designed to answer are quite different (e.g. PISA does not examine outcomes of skills), there is a strong statistical association between the two, and a volume of studies consider PISA as PIAAC determinant. Henceforth, we use LIT and NUM for both PISA (corresponding to Reading literacy and Mathematical literacy) and PIAAC cognitive skills domains. In Slovakia, six rounds of PISA were carried out. The results (based on plausible values) are displayed in Table 2.

Table 2: PISA results for Slovakia (2003–2018)

	LIT	SE	NUM	SE	science	SE
2003	469,2	(3,1)	498,2	(3,3)		
2006	466,3	(3,1)	492,1	(2,8)	488,4	(2,6)
2009	477,4	(2,5)	496,7	(3,1)	490,3	(3,0)
2012	462,8	(4,2)	481,6	(3,4)	471,2	(3,6)
2015	452,5	(2,8)	475,2	(2,7)	460,8	(2,6)
2018	458,0	(2,2)	486,2	(2,6)	464,0	(2,3)

Source: OECD PISA Data Explorer

PISA results for Slovakia feature a declining trend in all three areas, despite the fact that the uncertainty regarding the measurement and the relatively small number of observations in the time series must be taken into account in the interpretation. For analytical and forecasting purposes, only LIT and NUM domains demonstrate the desired comparability. The difference in the results of the LIT and NUM areas in both PISA and PIAAC justifies the modeling of these two areas separately.

For each area *j* and age category *i*, the PIAAC 2012 score is conceptually determined by the additive relationship

$$PIAAC_{ij} = \alpha_{ij} + \beta_j PISA_{ij} + \boldsymbol{\gamma}_j^{\mathrm{T}} \mathbf{X}^j \qquad (1)$$

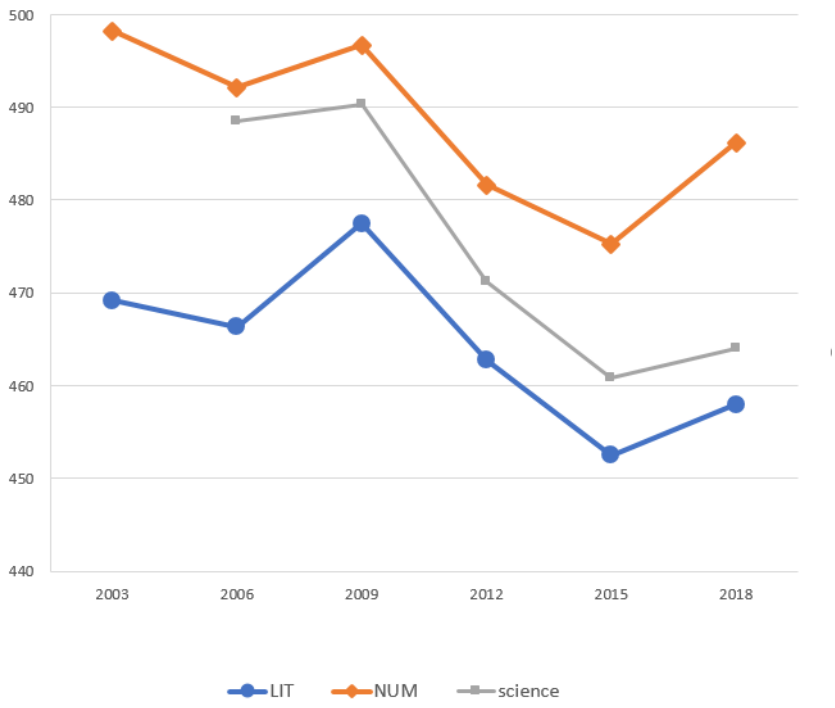
where the index and an example of the division into age categories *i* can be Table 2. In the relationship (1) the main determinant - the PISA score - is stated explicitly as an exogenous variable. Data on other potential determinants are included in the data matrix **X**, their effect on the PIAAC score is expressed by coefficients γ. The resulting PIAAC score is further formed by the α_{ij} component, in which the age and cohort effects are integrated. Incomplete data are also a challenge in estimating (1). $PISA_i$ values for the years 2003 - 2018 belong to only six $PIAAC_i$ age categories. Due to these data limitations, a reduced number of determinants and simplifying assumptions about their trends were used for forecasting purposes.

III. Trend Determinants and PIAAC 2030 projection

A structural relationship (1) with the following implementation steps is used to predict PIAAC values. The missing PISA data replace the PISA values obtained from the linear trend $PISA = \delta_0 + \delta_1 t$.

On average, LIT decreases by 1,067 points per year and NUM by 1,198 points. These values, according to findings from OECD countries, are highly variable across countries. However, the data for Slovakia show a good agreement with the results for the Czech Republic (a decrease of 1,1 for LIT and 1,27 for NUM). In empirical analyzes on data from 20 countries (Gustaffson, 2016), two determinants of PIAAC were used - the Human Development Index (HDI) and the change in acquired qualifications (EdQualif). The latter has good potential to capture the educational level of a particular sample, but as such is difficult to predict. In this way, the PIAAC score from the Slovak measurement is modeled only using past PISA and HDI results. Both variables determine the modeled value with the corresponding delay. It is assumed that e.g. The score of a PIAAC 2012 participant at the age of 24 is determined by his / her result in PISA 2003, while HDI2003 controls the "global" environment (Slovakia). For modeling and PIAAC 2012 and prediction of PIAAC 2030 values, trend values of determinants (i) from previous periods (to determine values for higher age groups in 2012) as well as (ii) in future periods (lower age groups in 2030) are needed.

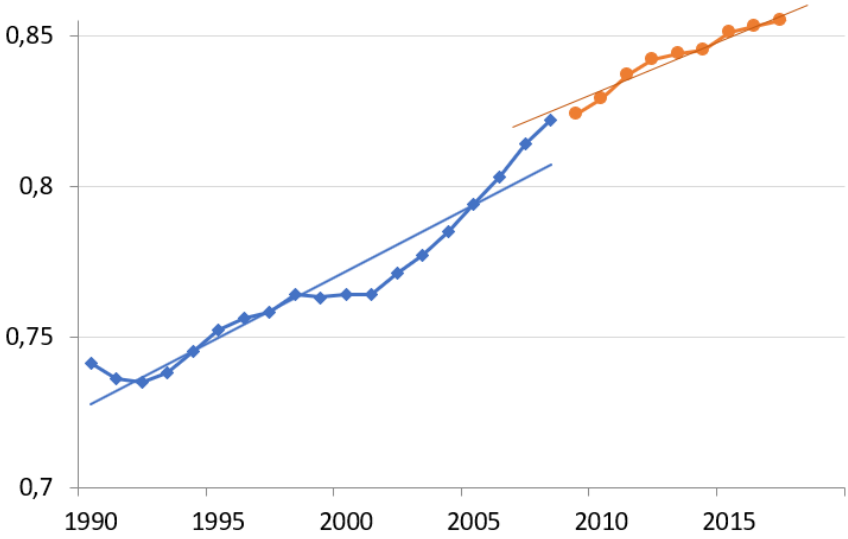
Figure 1: PISA results for Slovakia (2003 – 2018)



Source: OECD

Trend HDIs are determined by linear time trends with different parameters, from values before and after the statistically identified breakpoint at 2008 (Chow test F(2, 18) = 14,66 with p-value 0,00)

Figure 2: Human development index (Slovakia, 1990 – 2018)



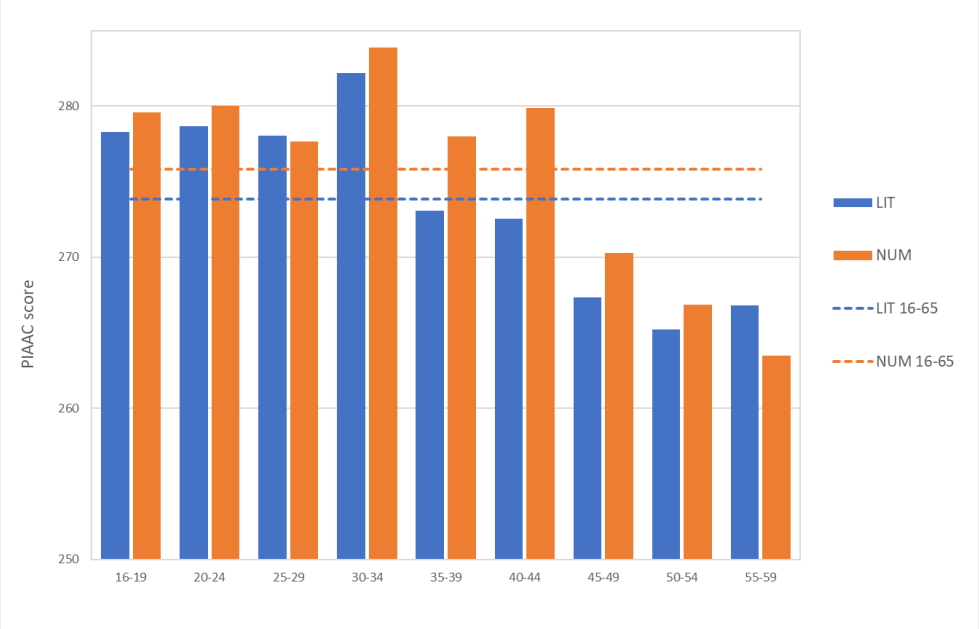
Source: Statista.com

Using the estimated regression coefficients β and γ, it is possible to determine for each age group (with the corresponding hypothetical value of the PISA and HDI result) the modeled trend value of the trend ("core") PIAAC value determined by purely selected determinants:

$$PIAAC_i = \beta PISA_i + \gamma HDI_i \ .$$

Trend values contain only information on the average expected content based on hypothetical performance in PISA supplemented by the impact of the socio-economic environment. Real data for Slovakia, empirical research across OECD member countries and knowledge of psychology testify to the influence of the age of cognitive ability itself. Their uneven distribution measured in PIAAC 2012 is shown in Figure 3.

Figure 3: Literacy and Numeracy by age group (PIAAC 2012, Slovakia)



Source: OECD

In the figure, a rugged distribution is evident, such as in LIT (25-29) or NUM (35-39), which disrupts "smooth" distribution across categories. We must attribute this heterogeneity to the complex influence of age or cohort. Some empirical analyzes (e.g. Gustaffson, 2016) analyze the average change in cognitive abilities measured by PIAAC over time in a sample of 22 OECD countries (not including Slovakia) between age cohorts of 16-19 and 25-29. For forecasting purposes, a similar calculation would need to be carried out for each pair of the adjacent age brackets. The distribution structure from the left part of the graph is partially supported by the PISA reassessment studies PISA-15 and PISA-24, which are, however, limited to the age groups of 15 and 24-year-old respondents. The enrichment of PIAAC data for the next time period could make a

significant contribution to the separation of age and cohort effects. In this respect, the expected measurement of PIAAC 2021 in Slovakia is also significant from a narrower analytical-forecasting point of view.

In an effort to minimize measurement errors as well as reduce excess granularity, only those age groups for which PISA results were available (3 years apart) were selected for trend calculation purposes. Calculations and forecasts are therefore performed for 16 age categories – 18, 21, ..., 63 years, for which the LIT and NUM averages (Table 3) acting as *PIAACij* were calculated from the PIACC 2012 results.

Table 3: Literacy and Numeracy for selected age (PIAAC 2012, Slovakia)

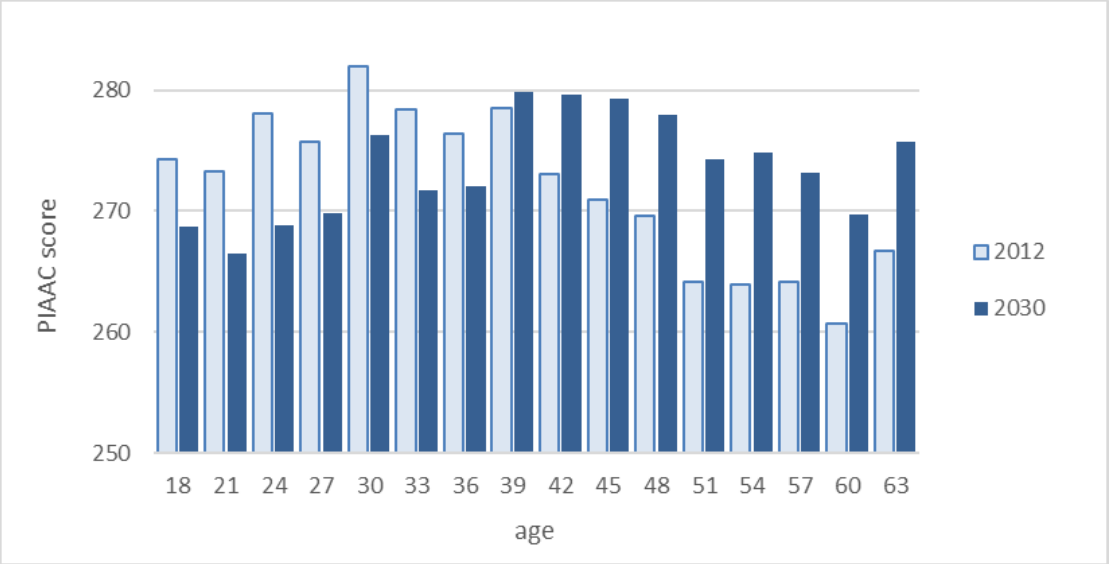
vek	N	LIT	SD_LIT	NUM	SD_NUM
18	155	274,2	(36,8)	278,1	(44,2)
21	159	273,2	(38,2)	273,1	(44,6)
24	108	278,1	(34,9)	280,2	(42,6)
27	119	275,7	(39,9)	274,3	(50,5)
30	120	281,9	(41,8)	285,8	(51,2)
33	116	278,3	(34,3)	276,5	(41,6)
36	115	276,4	(39,8)	277,2	(46,7)
39	134	278,5	(35,0)	281,5	(42,8)
42	96	273,0	(30,3)	282,1	(30,3)
45	113	270,9	(38,4)	280,0	(46,6)
48	135	269,6	(35,1)	277,6	(44,5)
51	109	264,1	(37,7)	264,2	(43,7)
54	111	264,0	(41,9)	265,7	(52,4)
57	133	264,2	(38,8)	265,5	(46,0)
60	127	260,7	(39,2)	259,9	(45,9)
63	107	266,7	(34,5)	262,0	(42,5)

Source: OECD, author´s calculation

Deviations of the trend PIAAC from the actual result of PIAAC 2012 are used to fix the structure of results by age categories. The whole difference (residual) is attributed to the combined effect of age and cohort. The projected PIAAC 2030 values are then created by transferring this structure to the underlying trend value in the future. The actual PIAAC 2012 values and the projected PIAAC 2030 values for the areas of reading and mathematical literacy are shown in Figure 4 and 5. Both forecasts show a strong influence of determinants on the predicted values. The regressions used maximized information that could be statistically explained from determinants, which in 2030 determine the relatively lower values of the underlying PIAAC trend component based on PISA and HDI, for all age groups. We thus find older age groups in both LIT and NUM perform better in 2030 than those in 2012

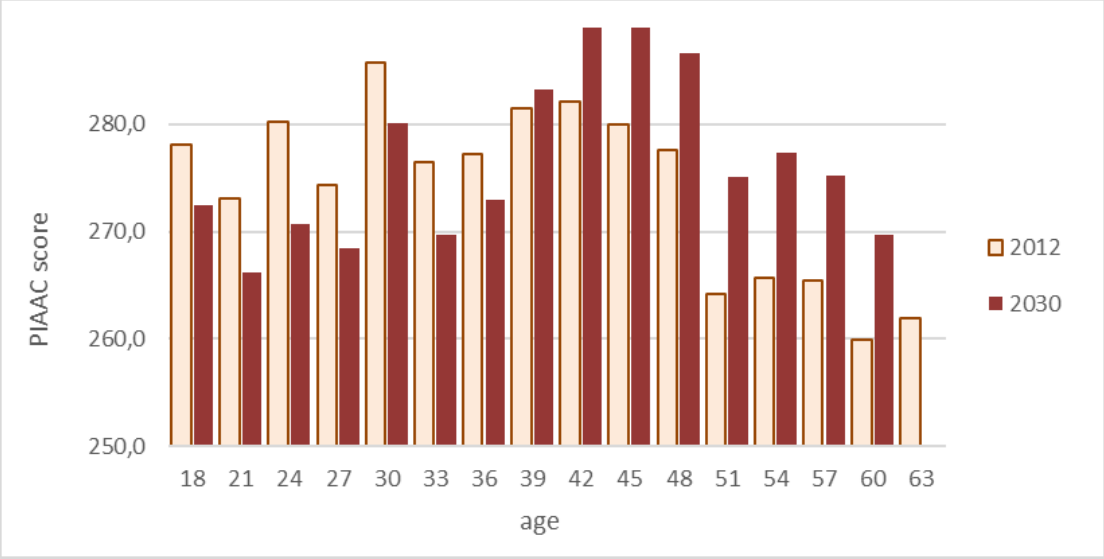
The cognitive "center of gravity" of the adult population shifts to older age. This scenario is thus largely determined by the negative development determined by the PISA results. For a particular cohort, the underlying LIT or NUM trend value remains the same over the course of the transition through the age groups over time and the age group related residuals apply to yield the final score. The justification for such an approach only rests in the lack of longitudinal or panel data that would allow to exploit the variation between cohorts and ages along with the cross-country average trend values.

Figure 4: PIAAC 2012 and PIACC 2030 (LIT) projections



Source: OECD, author´s calculation

Figure 5: PIAAC 2012 and PIACC 2030 (NUM) projections



Source: OECD, author´s calculation

IV. Conclusion and further research

The medium-term forecast is based on the assumption of a slight and slowing economic growth of the Slovak economy. A potential quality of labor supply has been identified. In the upcoming decade, most sectors of the economy will be affected by digitization, automation and the associated requirements for non-routine activities and continuous training. The cognitive abilities of an individual increase the probability of successfully coping with these changes. Predicted abilities expressed in predicted PIAAC scores suggest that the focus of cognitive abilities is shifting toward higher age categories. From this perspective, an effective educational policy is a challenge and an opportunity to influence an important determinant of learning abilities that is active throughout an individual's life.

The crisis caused by the COVID-19 supply shock may bring significant corrections to these medium-term forecasts. Despite the expected short-term nature, the ways of organizing work have been significantly affected and the tendencies towards digitization have intensified, with the consequences indicated above. The outlined trends may present a call for structural or even institutional reforms in socio-economic arrangement.

Methodologically compatible PISA and PIAAC measurements played a central role in the analysis and forecast of cognitive abilities. The results of the ongoing PIAAC round will allow the analysis of cognitive performance in cohorts. In establishing determinants, more controls in the PIAAC-on-PISA regression is expected to be involved. In particular, proxies for cohort and age group performance should be offered. To explore causal effects, panel data econometric techniques will be employed.

That will have a capacity to significantly improve the accuracy of human capital forecasts and refine estimates of the impact of cognitive determinants.

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