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Building on Human Capital to Restore Productivity Growth

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This Note shows that productivity has been slowing down in France over the last twenty years compared to Germany and the United States. This slowdown affects the majority of sectors and companies and constitutes a macroeconomic challenge of around 140 billion euros of GDP. This observation is challenging the traditional diagnosis of the French economic downgrading, according to which productivity would remain strong and the main problem would be a low employment rate. We focus our analysis on two drivers to accelerate productivity: human capital, an underused and failing lever in France, and business subsidies, a traditional lever used to compensate for a tax system historically perceived as punitive.

We show that human capital must become a top-priority lever, starting with education and the acquisition of mathematical and soft skills. These skills play a key role in productivity growth in modern economies. Yet France suffers from an educational dropout that affects even the best students. We estimate that a 10-point increase in mathematical skills –equivalent to that observed in Germany following the "PISA shock" in the mid-2000s– would lead to an increase in annual per capita growth of about 0.2 point.

We also propose a better allocation of human capital towards careers in science and innovation. Many students are turning away from these careers although they have the required skills to engage in, especially women and people from low-income backgrounds or disadvantaged territories. We recommend adopting a national strategy for innovation by all by developing interventions (career discovery workshops, role models, mentoring, internships) that are evaluated and proven to be effective. Such mobilisation of talents could increase economic growth by 0.2 percentage point.

Improving the quality and allocation of human capital could thus make it possible –within 15 years– to make up for the loss of productivity in relation to Germany and the United States observed since the mid-2000s.

Finally, regarding subsidies, surveys show that for most firms, difficulties in accessing funding have decreased over the last ten years. We suggest optimising direct subsidies for innovation, which are costly. The Research Tax Credit (*Crédit d'impôt recherche*, 7 billion euros per year) disproportionately favours large companies and should be redeployed to benefit small and medium-sized companies to be more effective.

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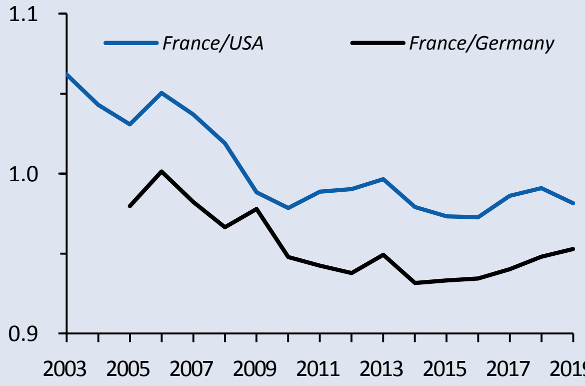
Anatomy of the productivity slowdown in France

Labour productivity has been falling behind Germany and the US for 20 years

Labour productivity is equal to the ratio between output and hours worked. Composition effects within the employed population require particular attention as they can bias labour productivity comparisons: the underemployment of the less skilled in France compared to our neighbours creates the illusion of higher productivity. Bourlès *et al.* (2012)[1] estimate that a one percentage point increase in the employment rate reduces labour productivity by 0.5%. By measuring the productivity of unemployed or inactive people according to their level of education, another study by the *Direction générale du Trésor* (DGT) estimates that if the employment rate in France were to increase by 10 percentage points, productivity would fall by around 2%.[2] It can therefore be estimated that the productivity bias is in the order of 0.2 to 0.5 per employment point.[3] As the employment rate of 15-64 year olds in France is 10 percentage points lower than in Germany (65% versus 75%), measured labour productivity would therefore fall by 2%-5% if France reached the German employment rate. Figure 1 presents adjusted labour productivity –relative to Germany and the US– assuming a bias of 0.35 (in the middle of the two estimates above) and using the OECD harmonised data for measuring employment rates, available from 2003 for France and 2005 for Germany.

Over the period from 2004 to 2019, France lost 7 points of GDP per capita compared to Germany and the relative decline in productivity explains about 5 points. Compared to the United States, the fall in productivity is even greater, around 7 points, corresponding roughly to the drop in French GDP per capita compared to the United States.[4] Thus, our findings call into question the traditional diagnosis of the French economic decline, according to which productivity would remain strong and the main problem would be a low employment rate. On the contrary, we show that the relative decline in productivity is at least as important as the decline in hours worked[5] to explain recent developments in GDP growth, and certainly more important in the future.

1. Adjusted labour productivity



Sources: BCL, OECD and authors calculation.

All sectors contribute to the decline in productivity

To analyse productivity dynamics at the sectoral level, we use the KLEMS database to calculate total factor productivity (TFP) –taking into account the role of capital, energy and intermediate inputs.[6] In manufacturing, there is no strong change in TFP compared to the US and Germany, which is not surprising in a sector of internationally traded goods: adjustment is through entries and exits into the sector.[7] In professional and scientific services, there is a relative decline after 2006 compared to the US. Compared to Germany, the positive trend visible since 1995 has come to a halt. Finally, in the commerce sector (wholesale, retail, including car repair) and construction, the trends are very negative compared to Germany.

For these same sectors, we can compare the allocation of labour input. In KLEMS, the quantity of labour index measures the hours worked weighted by the qualification (education) of workers. We observe a strong decrease in the human capital allocated to industry compared to Germany, of 20 points over 20 years: this has a negative impact on the average labour productivity as it is higher in industry than in other sectors. In construction, the opposite phenomenon is at work: France allocates more human capital in a sector where TFP is low. In information and communication technologies, the trends are also alarming, with TFP falling sharply compared to the

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[1] Bourlès R., G. Cette and A. Cozarenco (2012): "Employment and Productivity: Disentangling Employment Structure and Qualification Effects", *International Productivity Monitor, Centre for the Study of Living Standards*, vol. 23, pp 44-54.

[2] Direction Générale du Trésor (2018): *Comparaisons internationales de productivité horaire et lien avec le niveau du chômage ou du taux d'emploi*, Mimeo.

[3] The *Direction Générale du Trésor* (DGT, French Treasury) study gives a low range because it does not take into account the unobserved heterogeneity between the unemployed and the employed. The study by Bourlès *et al.* (2012, *op. cit.*) gives a high range instead.

[4] Girard P.L., B. Le Hir and D. Mavridis (2022): "Dynamiques sectorielles et gains de productivité", *Note d'Analyse de France Stratégie*, no 105, January.

[5] Taking into account that a one percentage point increase in the employment rate goes hand in hand with a 0.5% reduction in labour productivity, an increase in the current employment rate from 65% to the German level of 75% would lead to a 5% increase in GDP.

[6] According to KLEMS, French TFP has fallen by 5-6 points relative to the United States and 7-8 points relative to Germany since 2000, a finding comparable to that made on the basis of Bergeaud A., G. Cette and R. Lecat (2016): "Productivity Trends in Advanced Countries between 1890 and 2012", *Review of Income and Wealth*, vol. 62, no 3, pp. 420-444. If we restrict ourselves to the market sector, the drop is even greater, around 10 points.

[7] A phenomenon documented for the automotive industry in Head K., P. Martin and T. Mayer (2020): "Les défis du secteur automobile: compétitivité, tensions commerciales et relocalisations", no 58, July.

US and Germany. The decline relative to the US begins in the 1990s, a period of strong growth in the US driven by new information and communication technologies (NICTs), a phenomenon less observed in France (Cette *et al.*, 2009; Biagi, 2013).[8]

The above analyses reveal several points:

- TFP is slowing down sharply in several sectors, notably construction and commerce;
- Skilled services that traditionally contributed to France's good productivity have not done so since the 2000s;
- In manufacturing, measured productivity is stable but the composition effect is negative.

The finding of a significant decline in productivity growth in the early 2000s is also reflected in data from individual firms.[9] To estimate the role of factor reallocation in the slowdown in labour productivity, David *et al.* (2020)[10] propose a decomposition of aggregate productivity gains from the FICUS-FARE database. This study shows that there is indeed a decline in the contribution of reallocation to productivity growth, but it is too small to explain the fall in labour productivity growth over the recent period. By far the largest contributor to the fall in aggregate productivity is the internal growth effect.[11] This finding is consistent with that made by Gutierrez *et al.* (2021)[12] on ORBIS data at the level of industrial firms in Europe: growth has fallen mainly because of small productivity gains within firms themselves, not because of a fall in reallocations.

A GDP shortfall of 140 billion euros

The relative decline in French productivity has reduced GDP by about 5.8 percentage points. This represents a shortfall in GDP of around €140 billion in 2019,[13] i.e. around €65 billion in tax revenue with a compulsory levies rate of 46%, i.e. the same order of magnitude as the annual budget of the Ministry of National Education (€52 billion in 2019, excluding contributions to state pensions) and debt servicing (€40 billion in 2019). The stalling of productivity in France, therefore, has major consequences for economic activity and public finances.

Finding 1. The slowdown in productivity in France between 2004 and 2019 compared to Germany and the United States represents a GDP shortfall of 140 billion euros for France in 2019, or about 65 billion in annual tax revenue.

Since all sectors and firms contribute to the productivity slowdown in France, in the remainder of this *Note* we analyse the factors that affect the whole economy: human capital and innovation subsidies.

Dropping out of math and soft skills: a significant risk to productivity

The effects of human capital on productivity

Quantifying the link between skills and productivity poses several methodological difficulties, as it is not easy to isolate causal phenomena or to take into account general equilibrium effects. The literature has developed several methods that collectively overcome these difficulties. Thus, we analyse the role of mathematics and soft skills for productivity according to different methodologies (see box below). Regardless of the methodology used, mathematical and soft skills play a prominent role in the labour market and for growth.

Educational drop-out affecting even the best students

Having established the growing importance of mathematical and soft skills, we now show that France performs poorly in these key areas. The supply of skills in France is low today and has been declining over the past decades, even for the best students.

The level and evolution of French results in mathematics have been the subject of several recent analyses.[14] These concur with the observation of a clear deterioration in the average level but remain ambiguous concerning the evolution at the top of the distribution, following the widespread idea that the best French pupils continue to perform very well in mathematics. We confirm here the observation of a general deterioration

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[8] Cette G., Y. Kocoglu and J. Mairesse (2009): "Productivity Growth and Levels in France, Japan, the United Kingdom and the United States in the Twentieth Century", *NBER*, no w15577. Biagi F. (2013): "ICT and Productivity: A Review of the Literature", *JRC Working Papers on Digital Economy*, no 2013-09.

[9] Cette G., S. Corde and R. Lecat (2016): "Stagnation de la productivité en France: héritage de la crise ou ralentissement structurel ? ", *Économie et Statistique*, no 494-495-496.

[10] David C., R. Faquet and C. Rachiq (2020): "Quelle contribution de la destruction créatrice aux gains de productivité en France", *Working Paper DG Treasury*, no 2020/5.

[11] According to David *et al.* (2020, *op. cit.*), the weighted average of labour productivity in perennial firms has increased by only 0.3 percentage points in the recent period; in the period 2001-2007, this average had increased by more than 5 percentage points.

[12] Gutierrez G., J. Martinez, T. Philippon and S. Piton (2021): *The Evolution of Firm Heterogeneity in Europe: Facts and Explanations*, Mimeo.

[13] According to Figure 1, the relative productivity decline in France was 5.8%, taking the average of the declines seen in Germany (– 4.7%) and the US (– 7%). With 2019 GDP of EUR 2 426 billion, 5.8% represents EUR 140.7 billion.

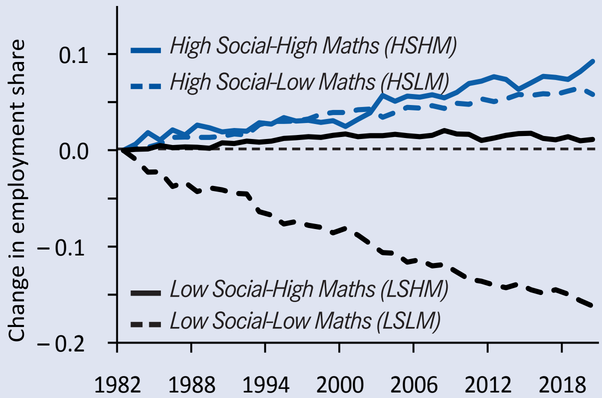
[14] See Villani C. and C. Torossian (2018): *21 mesures pour l'enseignement des mathématiques*, Rapport 'Villani-Torossian' de la mission 'Mathématiques', 12 February; Longuet G. (rap.) (2021): "Réagir face à la chute du niveau en mathématiques: pour une revalorisation du métier d'enseignant", *Rapport du Sénat de Commission des finances sur l'enseignement des mathématiques*, no 691 (2020-2021); DEPP (2022): "L'état de l'École 2021", *Analyse statistique du système éducatif*, no 31.

Quantifying the role of mathematics and soft skills in productivity growth

Sectoral analyses on the demand for skills

To analyse the evolution of the importance of different skills between 1982 and 2020, we replicate for France the work of Deming (2017)[a] on social skills in the US, using data from the Occupational Information Network (O*NET), which measures the skill content of occupations in the US economy. Occupations are classified into one of four mutually exclusive task categories: High Social-High Math (HSHM), High Social-Low Math (HSLM), Low Social-High Math (LSHM), and Low Social-Low Math (LSLM), based on whether they fall above or below the median percentile for task intensity in maths and social skills (part of soft skills). The method and results are detailed in Guadalupe and Ng (2022).[b]

Cumulative changes in employment share by occupation task intensity



Source: Guadalupe M. and B. Ng (2022): "Soft Skills and Productivity in France", *Focus du CAE*, no 092-2022, September.

The distribution of employment across the four occupational task categories has changed over time, with an increase in occupations requiring mathematical and social skills (graph). In France, between 1982 and 2020, HSHM occupations increased by 9.2 percentage points, including production and operations managers, engineers, architects, IT professionals, health workers and teachers. Over the same period, LSLM occupations decreased by 16.2 percentage points, with a decline in assemblers, agricultural workers, machine operators, secretaries and office workers.

These results show the growing importance of social and mathematical/analytical skills for employment in France, similar to what has happened in the US (Deming, 2017, *op. cit.*). Moreover, the sectoral regressions show a correlation between the growth of TFP in a sector and the skills of the workforce: TFP increased significantly in sectors with a high concentration of HSHM, while it fell in sectors with a low concentration of HSHM –mainly at the time of the financial crisis in 2008.

Cross-country regressions

The literature on cross-country regressions shows the importance of human capital for growth, especially mathematical skills. We replicate the methodology of Hanushek and Kimko (2000)[c] and extend their results to a more recent period using data from the Programme for International Student Assessment (PISA) survey to measure mathematical skills in 60 countries. We study the relationship between 2012 PISA scores and the annual growth rate of GDP per capita between 2000 and 2019.[d] We find that mathematical skills are strongly correlated with a country's growth, while years of schooling is not. A one standard deviation increase in PISA maths scores (about 50 points) would result in an increase in the annual growth rate of between 1.1 and 1.7 percentage points. This result is consistent with the estimate of Hanushek and Woessmann (2012),[e] who calculate an education quality score using alternative standardised tests, as well as with other cross-country analyses showing that human capital explains more than half of the variation in GDP *per capita* across countries (Jones, 2014; Malmberg, 2017; Hendricks and Schoellman, 2018).[f] Other studies assess the effects of public policies inducing geographical

a Deming D.J. (2017): "The Growing Importance of Social Skills in the Labor Market", The Quarterly Journal of Economics, vol. 132, no 4, pp. 1593-1640.

b Guadalupe M. and B. Ng (2022): "Soft Skills and Productivity in France", Focus du CAE, no 092-2022, September.

c Hanushek E.A. and D.D. Kimko (2000): "Schooling, Labor-Force Quality, and the Growth of Nations", American Economic Review, vol. 90, no 5, pp. 1184-1208.

d Average increase over 19 years, for more details, see Martin R., T. Renault and B. Roux (2022): "Baisse de la productivité en France : échec en 'maths' ?", Focus du CAE, no 091-2022, September.

e Hanushek E.A. and L. Woessmann (2012): "Do Better Schools Lead to More Growth? Cognitive Skills, Economic Outcomes, and Causation", Journal of Economic Growth, vol. 17, no 4, pp. 267-321.

f Jones B.F. (2014): "The Human Capital Stock: A Generalized Approach", American Economic Review, vol. 104, no 11, pp. 3752-77; Malmberg H. (2017): Human Capital and Development Accounting Revisited, Mimeo Institute for International Economic Studies; Hendricks L. and T. Schoellman (2018): "Human Capital and Development Accounting: New Evidence from Wage Gains at Migration", The Quarterly Journal of Economics, vol. 133, no 2, pp. 665-700.

variation in access to education within a country and show a significant effect of rising human capital on economic activity, including when general equilibrium effects are taken into account (Khanna, 2022).[g]

Macro-econometric analysis for France

Aussilloux *et al.* (2020)h propose an econometric decomposition of French growth. Their results suggest that human capital –measured from the number of years of education– contributes to the majority of productivity gainś between 1971 and 2018. According to their estimate, the slowdown in the growth of the level of initial education –after the strong democratisation of education between 1975 and 2000– explains more than half of the productivity slowdown since 2000.

Sectoral regressions

Cross-country regressions may contain composition biases due to changes in the structure of economies. We therefore extend our study with a sectoral analysis that confirms the importance of mathematical and soft skills for productivity. Using the PIAAC database we find a significant positive relationship between mathematics scores and the level of sectoral productivity net of fixed effects for the 9 sectors and 29 countries included (see Martin et al., 2022, op. cit.).

Regressions at the individual level

Finally, we estimate the returns to mathematical and soft at the individual level. A one standard deviation increase in soft skills is associated with a 3.6% increase in hourly wages (see Guadalupe and Ng, 2022, *op. cit.*), which is higher than the increase associated with a one standard deviation increase in mathematical skills. Our results are consistent with a meta-analysis conducted by the European Commission,i the results of experimental studies evaluating the effect of management and communication skills trainingj , and the recent literature showing a positive causal effect of soft skills training (Katz *et al.*, 2021; Algan *et al.*, 2022)k on individual earnings.

[g] Khanna G. (2022): "Large-Scale Education Reform in General Equilibrium: Regression Discontinuity Evidence from India", *Journal of Political Economy*, forthcoming.

[h] Aussilloux V., C. Bruneau, P-L. Girard and D. Mavridis (2020): "Le rôle du capital humain dans le ralentissement de la productivité en France", *Note de Synthèse de France Stratégie*, December.

[i] Cabus S., J. Napierala and S. Carretero (2021): "The Returns to Non-Cognitive Skills: A Meta-Analysis", JRC Working Papers Series on Labour, *Education and Technology*, no 2021/06. This paper summarises 333 estimates from 29 empirical papers conducted between 2009 and 2019, examining the association between personality traits and earnings.

[j] Studies in the retail and manufacturing sectors in Chile and India have established a causal relationship between soft skills training programmes and productivity at the firm and individual level (see Prada M.F., G. Rucciand and S. Urzúa (2019): "Training, Soft Skills and Productivity: Evidence from a Field Experiment in Retail", *IDB Working Paper Series*, no 1015, and Adhvaryu A., N. Kala and A. Nyshadham (2018): "The Skills to Pay the Bills: Returns to on-the-Job Soft Skills Training", *National Bureau of Economic Research*, no 24313.

[k] Katz, L.F., J. Roth, R. Hendra and K. Schaberg (2021): *Why Do Sectoral Employment Programs Work? Lessons from WorkAdvance*, JOLE Virtual Conference 2020; Algan Y., E. Beasley, S. Côté, J. Park, R.E. Tremblay and F. Vitaro (2022): "The Impact of Childhood Social Skills and Self-Control Training on Economic and Noneconomic Outcomes: Evidence from a Randomized Experiment Using Administrative Data", *American Economic Review*, vol. 112, no 8, pp. 2553-79.

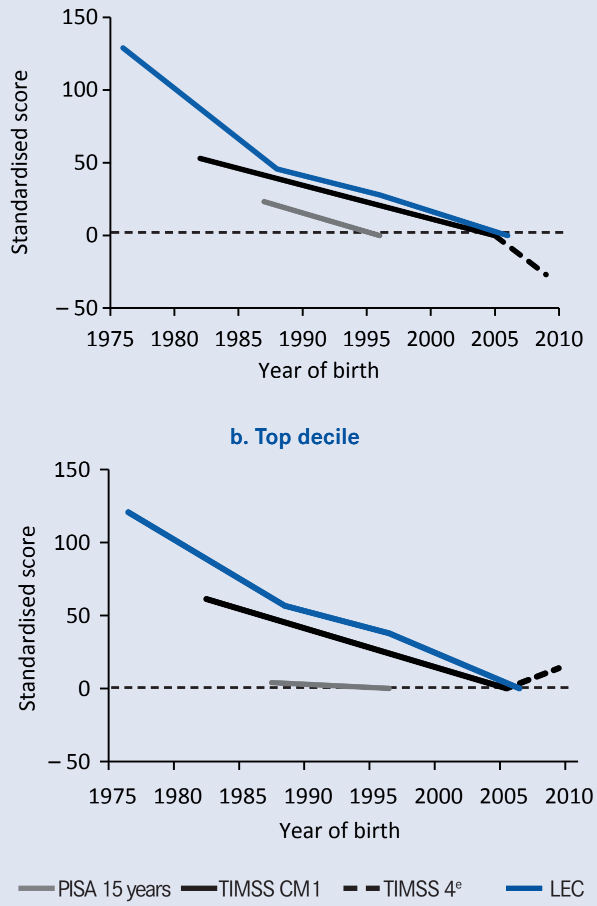
in the level in France and show that this observation also applies to the best scores in the distribution, particularly over the recent period. We use data from four sources: the PISA survey (for 15-year-old students), the TIMSS surveys (at the end of primary and lower secondary schools), and the DEPP's "*Lire, écrire, compter*" and CEDRE studies (at the end of primary and lower secondary schools). We observe a continuous deterioration over time, here according to the year of birth of the pupils concerned by the survey, within the lower and upper deciles of the score distribution (Figure 2a and b). The decline in average scores is of the same order of magnitude and is documented in a DEPP study (2022, *op. cit.*).

The downward trend in mathematics scores in France has led to a decline in our country's rankings in international surveys. In the PISA surveys from 2012 to 2018 France ranks around 20th in mathematics among the 37 OECD countries that took part in the survey. The results of the TIMSS survey on CM1 students (primary school) are even more alarming: out of the 21 countries that participated in the survey in 1995 and 2019, France has dropped from 7th to 17th and is ranked 16th out of the 18 OECD countries included in the study in 2019. Moreover, we observe, in both PISA and TIMSS, a marked decline in the ranking of the best students. Thus, in the 2019 TIMSS survey of lower secondary school pupils, France is ranked 29th out of 38 countries for the average score of the top decile of mathematics scores. In line with the results for the whole distribution, the 2018 PISA survey places France 20th out of 37 OECD countries in the ranking of the 90th percentile of scores in each country. The results are similar for the top 5% and 1% and invalidate the idea that the best French students are not representative of the aggregate results and are at the top of the global distribution.

France's performance in soft skills is also disappointing. The French deficit in this area relative to other OECD countries has been documented in several surveys and analyses. OECD data on skills for employment show that France has a skills deficit compared to the United States in the following

2.Evolution of the average level of mathematical skills in the assessments (in %)

a. Bottom decile



Interpretation: Pupils born in 1976 and belonging to the lowest decile obtained a standardised score of 129% in the LEC (*Lire, écrire, compter*) survey in CM2.

Note: The values represented are obtained by mobilising and standardising the scores collected in all the surveys that evaluate the level of mathematics through a scale of scores, the aim being to make it possible to compare scores over time despite different evaluation scales.

Sources: DEPP-MENJS/IEA/OECD and authors calculation.

dimensions: instruction, coordination, social perception, negotiation, complex problem solving, judgement and decision making, and resource management.[15] This deficit is widespread among both students and adults. PISA shows that French students are less persistent and cooperative, less effective in problem solving, and have lower levels of internal locus of control compared to the US, Germany and Northern Europe.

We estimated the soft skills deficit of French adults relative to 17 other developed countries using data from the OECD's Programme for the International Assessment of Adult Competencies (PIAAC) (Guadalupe and Ng, 2022, *op. cit.*). This analysis reveals that the average level of soft skills in France is disappointing, just above Germany and Japan and well below that of the US, Denmark and the UK; this gap is also found among adults with a university degree. Furthermore, the gap in soft skills in France between people with and without a graduate degree is among the largest.

Thus, the transmission of soft skills through education and vocational training in France is insufficient to meet the demands of the economy, and France has a deficit compared to other developed economies (see in this regard, Algan *et al.,* 2018).[16] This is all the more alarming as the literature establishes that soft skills are also important for the acquisition of cognitive skills (Heckman and Kautz, 2012; Huillery *et al.*, 2021).[17]

Upgrading human capital at the core of the productivity acceleration strategy

The above results allow us to appreciate the order of magnitude of the impact of human capital on growth. Using the results of *cross-country* regressions, we find that a 10-point increase in France's PISA scores –about one-fifth of the gap between France and the top countries in the ranking and half the gap with Germany in the estimation year–[18] corresponds to an increase in growth of 0.20 percentage point each year in the long run. Over fifteen years, this additional growth would lead to an increase in GDP of about 3%, or about 75 billion in constant 2019 euros.[19]

> **Finding 2.** The level of students in France is low and declining, including for the best students; strengthening human capital, particularly in soft and mathematical skills, would have a significant impact on productivity and therefore on the standard of living of the French and tax revenues.

[15] OECD (2017): *Getting Skills Right: Skills for Jobs Indicators*, OECD Publishing, Paris.

[16] Algan Y., É. Huillery and C. Prost (2018): "Trust, Cooperation and Autonomy: Towards a 21st Century School", *Note du CAE*, no 48, October.

[17] Heckman J.J. and T. Kautz (2012): "Hard Evidence on Soft Skills", *Labour Economics*, vol. 19, no 4, pp. 451-464; Huillery É., A. Bouguen, A. Charpentier, Y. Algan and C. Chevallier (2021): "The Role of Mindset in Education: A Large-Scale Field Experiment in Disadvantaged Schools", *Working Paper Sciences Po*, no 2270.

[18] A 10-point increase in PISA scores is also roughly equivalent to the improvement observed in Germany (11 points) between 2003 and 2012, following the so-called 'PISA shock› reforms.

[19] The time between the implementation of an educational reform and an increase in productivity varies according to the age of the target audience and the diffusion of productivity gains between generations. The time horizon for observing the full effects of an educational reform is actually around 60 years. For example, Hanushek E.A. and L. Woessman (2020): "A Quantitative Look at the Economic Impact of the European Union's Educational Goals", *Education Economics*, vol. 28, no 3, pp. 225-244, estimate that a 25-point increase in PISA would lead to a 30% increase in GDP in 2100 (80 years ahead).

Identifying precisely the investments and reforms that would reliably increase human capital in the French case is beyond the scope of this *Note*, but we have empirical analyses that can guide the implementation of public policies to curb educational dropout and strengthen the links between education and economic performance (see Fryer, 2017, for a meta-analysis of nearly 200 randomized controlled trials on human capital in developed countries; see also Deming, 2022).[20]

Despite the importance of the issue, education is not high enough on the agenda in the economic debate. The stagnation of the national education budget illustrates this well: taking inflation into account, French teachers have lost between 15 and 25% of their salaries over the last twenty years.[21] Even if several reforms have been undertaken in recent years (the duplication of the number of first grade classes in the priority school network, support measures such as "*devoirs faits*" or "*vacances apprenantes*", Parcoursup, reform of the *Baccalauréat*, etc.), we still have a lot of room for improvement. In particular, the measures taken are focused on 'dropouts›, whereas the decline in French education is widespread, even for the best students. Furthermore, there is no in-depth diagnostic work on the reasons for this decline, with a few exceptions such as the Villani-Torossian report on mathematics. Lastly, evaluations show that the measure of duplicating classes has produced effects, but on a small scale in relation to the backlog to make up.[22]

In order to stop this educational dropout, the priority should be to set ambitious goals. First of all, we propose that we collectively set an ambitious and legally binding long-term objective for national and international tests, along the lines of the long-term objectives that guide the national low-carbon strategy. Achieving this goal requires structural reforms, which could be based on examples of large-scale reforms carried out abroad. For example, Germany and Portugal reacted strongly to their poor performance in international PISA surveys in the 2000s and have made a dramatic recovery, demonstrating that it is possible to make significant progress in just five years. The reforms implemented are described in Martin *et al.* (2022, *op. cit.*). Their example should serve as an inspiration for structural measures: conducting an in-depth diagnostic study, involving teachers, on the causes of the decline in French education, improving teacher training, making the teaching profession more attractive, strengthening the autonomy of schools, creating a new independent monitoring body to evaluate and support the improvement of the education system, etc. Some of the reforms could be an extension of measures initiated during the previous five-year term, for example by focusing on the rapid implementation of the 21 measures for mathematics teaching in the Villani-Torossian report.

Thus, by 2027, it is possible to significantly improve the results of all pupils, including the highest-performing ones, in national and international standardised tests in primary, lower and upper secondary schools. Another objective for 2027 would be to significantly reduce inequalities between schools, for example by devoting more resources (human and budgetary) to schools in difficulty, with a view to catching up. Reforms could also be based on the results of studies that identify successful schemes, such as boarding schools of excellence, which have a proven causal effect on pupils from modest backgrounds.[23]

> **Recommendation 1.** Establish a national strategy with ambitious goals to significantly improve the achievement of pupils in primary, lower secondary and upper secondary schools, including the highest achieving pupils.

This 'national educational strategy for excellence and equal opportunities should be developed in consultation with all stakeholders, including teachers and parents. It could even lead to the establishment of a citizens convention and a High Council, independent of the Ministry, on the model of the institutions supporting the national low-carbon strategy.

This strategy should also promote the improvement of soft skills, which must be done by reinforcing the importance of these skills in school curricula (on this subject, see the detailed recommendations in Algan *et al.*, 2018, *op. cit.*). In order to be able to systematically monitor the status and development of soft skills in schools, it would be important to introduce standardised tests, just as there are annual assessments in mathematics and French carried out at the beginning of primary and secondary school. In the United States, California has developed the *California Healthy Kids Survey* (CHKS), which since 2019 has measured the performance of schools in *soft skills*. In France, the DEPP is already involved in an effort to evaluate certain aspects of student behaviour.[24] However, in order to structure ambitious public policies with objectives on improving *soft skills*, the

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[20] Fryer Jr R.G. (2017): "The Production of Human Capital in Developed Countries: Evidence from 196 Randomized Field Experiments", *Handbook of Economic Field Experiments*, vol. 2, pp. 95-322; Deming D.J. (2022): "Four Facts about Human Capital", *National Bureau of Economic Research*, no w30149.

[21] Longuet (rap.) (2021, *op. cit.*).

[22] The evaluation of the impact of the reduction in the size of CP and CE1 classes in REP+ on pupils' results and teachers' practices by the DEPP (2021, *op. cit.*) estimates the effect of duplicating classes on pupils' mathematical skills at 14 per cent of the standard deviation between the beginning of CP and the end of CE1, thereby closing 38 per cent of the gap observed at the beginning of CP between REP+ pupils and pupils outside the priority education network.

[23] See Behaghel L., C. de Chaisemartin and M. Gurgand (2018): "Avoir le bac : les effets de l'internat d'excellence de Sourdun sur la scolarité des élèves", *IPP Retours d'expérience*, no 3 August,

[24] DEPP (2019): "La motivation et le sentiment d'efficacité des élèves baissent de façon socialement différenciée au cours du collège", *Note d'information*, no 19.02, March.

evaluation procedures should be extended to all schools, include other personality traits, and be carried out on a regular basis.

> **Recommendation 2.** Set medium- and long-term targets with a system of regular assessment of soft skills for students on a national scale.

Promoting a National Strategy for Innovation by All

In this section, we analyse another lever for accelerating productivity: better guiding young people towards careers in science and innovation.

Strong disparities in access to careers in innovation according to social background

The propensity to pursue careers in science, innovation and entrepreneurship depends largely on family background (parental income, education and occupation), territory of origin and gender. The literature shows, for example, that for the same school performance, in the US, the probability of becoming an innovator is 7 times higher for a child whose parents are in the top of 1% the income distribution, compared to those below the median (Bell *et al.* , 2019).[25] Similar results have been obtained in Finland (Aghion *et al*., 2017)[26] and in developing countries (Agarwal and Gaule, 2020).[27] Our contribution in this *Note* is to show that similar trends are at work in France.

In order to identify the young people who go into science, entrepreneurship and innovation careers from the CEREQ data, we observe the share of young researchers and engineers holding a PhD degree in each social origin category. Graph 3 shows the evolution of these rates according to social origin. The trend of the relationship is always increasing, i.e. it is much more frequent to become a researcher or engineer and to hold a PhD degree within the well-to-do.

We find that the bias exists even among the most successful researchers. To establish this, we look in turn at the share of individuals who obtain funding from certain particularly selective higher education institutions (ENS and École Polytechnique), as well as at the number of publications at the time of the survey, which is another measure of researchers' professional success. These results show that the insufficient mobilisation of talents also concerns researchers and innovators with very high potential –the so-called "*Lost Einsteins*" phenomenon.[28]

Furthermore, we find that the same trends are at work for the creators of patents or companies, who are much more likely to come from privileged to very privileged backgrounds.

In addition to the parents' income, there are also considerable disparities according to gender and region of origin. For example, the probability of becoming a researcher varies substantially between departments: one standard deviation corresponds to an increase in the innovation rate of almost 50%. The associated *Focus* by Feng *et al.* (2022) provides a detailed description of these disparities.[29]

For example, if children from less advantaged backgrounds and women had a similar rate of innovation to boys from more advantaged backgrounds, there would be 2.84 times more researchers or engineers holding a PhD degree in France than there are now. This result illustrates the potential of a policy aimed at mobilising all talents. Nevertheless, this analysis does not take into account possible general equilibrium effects and does not allow us to obtain an order of magnitude of the impact on economic growth. Later, we address these points by developing an endogenous growth model.

> **Finding 3.** In France, there are major inequalities in access to the professions of science, innovation and entrepreneurship according to family or territorial origins and gender, which slows down economic growth.

Impact of insufficient talent mobilisation on economic growth

In order to quantify the macroeconomic impact of the insufficient mobilisation of talent described above, we develop an endogenous growth model. We focus on gender inequalities, with the understanding that the insufficient mobilisation of individuals from disadvantaged backgrounds should further reinforce the macroeconomic impact.

We calibrate this model by assuming that it is possible, with the help of a public policy instrument, to increase by 30% the number of women choosing a career in the innovation sector (in a broad sense, i.e. including scientific professions, entrepreneurship, etc.). We also assume that it is possible

[25] Bell A., R. Chetty, X. Jaravel, N. Petkova and J. Van Reenen (2019): "Who Becomes an Inventor in America? The Importance of Exposure to Innovation", *The Quarterly Journal of Economics*, vol. 134, no. 2, pp. 647-713.

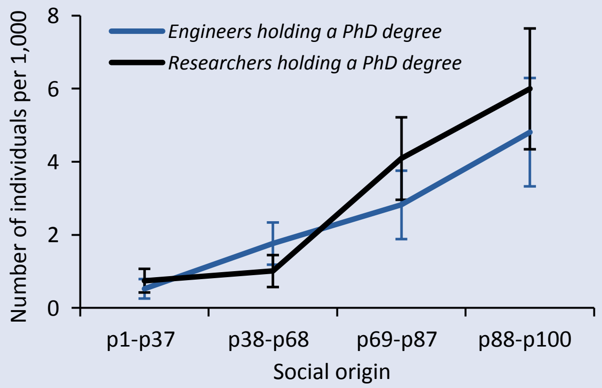
[26] Aghion P., U. Akcigit, A. Hyytinen and O. Toivanen (2017): "The Social Origins of Inventors", *National Bureau of Economic Research*, no w24110.

[27] Agarwal R. and P. Gaule (2020): "Invisible Geniuses: Could the Knowledge Frontier Advance Faster?", *American Economic Review: Insights*, vol. 2, n0 4.

[28] See Bell *et al.* (2019, *op. cit.*). Using detailed data on educational outcomes, this study shows, among other things, that social determinism in access to innovation careers exists even among individuals with the same aptitude for science.

[29] Feng J.J., X. Jaravel and É. Richard (2022): "Pour une stratégie nationale d'innovation par tous", *Focus du CAE*, no 089-2022, September.

3. Share of individuals who become researchers or engineers holding a PhD degree by social origin



Reading: Out of one thousand respondents from a disadvantaged background (p1-p37), less than one individual is a researcher holding a PhD degree and less than one individual is an engineer holding a PhD degree. Out of one thousand respondents from a very privileged background (p88-p100), 5 are researchers with a PhD degree and 6 are engineers holding a PhD degree. Since the size of the social origin groups varies, each point should be multiplied by the relative weight of the group (0.37 for the most disadvantaged group, then 0.30, 0.18 and 0.12 respectively) in order to obtain the total number of engineers and researchers in the entire population.

Source: CÉREQ Survey 2016 on generation 2013.

to target the scheme at high-potential individuals at the top of the innovation capacity distribution.[30] In practice, it is possible to target the most promising students according to their academic level. These assumptions are supported by the results of randomised experiments that demonstrate the possibility of guiding the career choices of young girls through simple information workshops.[31]

The simulation results summarised in Table 1 provide two lessons. First, the gains can be large. Economic growth depends on a small number of innovators (< 1% of the population) and attracting these "high potential innovators", previously unaware of these careers, can have a strong impact on the rate of economic growth. Secondly, the gains depend strongly on the quality of the targeting of the policy to raise awareness of science and innovation careers, since the largest effects are achieved by attracting ‹high potential innovators› from the under-represented group. According to the simulation with our baseline parameters (row 2 in Table 1), a strategy to mobilise talent would have the potential to increase economic growth by 0.2 percentage point, or an additional 5 billion euros each year.[32]

How can we encourage people to take up careers in science and innovation?

Given the macroeconomic stakes and the proven effectiveness of some levers, we propose to develop a national strategy aimed at increasing vocations for science and innovation careers. A large number of associations are already contributing to this objective,[33] but they do not benefit from permanent funding or evaluation procedures that would enable the public authorities to identify good practices and disseminate them on a national scale. There is currently no mechanism for coordinating initiatives and ensuring that they are properly tailored to macroeconomic challenges.

The strategy of innovation by all would rest on four pillars. Firstly, we propose to formalise a partnership between the State and a group of associations on the model of the *Mentorat* group and the "*1 jeune 1 mentor*" plan, broadening their scope –for example with new initiatives that could be called "1 young person 1 internship" or "1 young person 1 meeting". This partnership approach, centred on the work of associations in high schools and colleges, would have a budget of 100 million per year, so that each young person can be reached several times during their schooling. It would also involve setting up an evaluation procedure to identify the good practices of each of the associations involved and disseminate them on a national scale. Compared to the current situation, this approach would give associations more visibility on available funding, increase available resources and allow for better evaluation. This partnership strategy with the associations would take the form of multi-annual calls for projects to identify and disseminate the best initiatives related to internships, mentoring, workshops and innovation competitions for high school and college students.

1. Calibrating the effects of "innovation by all" policies on growth

Simulated public policy	Share of women among innovators (%)	Annual productivity growth rate (%)
Statu quo	12	0.90
30% increase in the number of female innovators among the top 0.05% of women	15	1.07
Full awareness of all women	50	1.54

Source: Feng J., X. Jaravel and É. Richard (2022): "Pour une stratégie nationale d'innovation par tous", *Focus du CAE*, no 089-2022, September.

[30] The calibration parameters and model results are described in the associated *Focus*, Feng *et al*. (2022, *op. cit*).

[31] For example, Breda T., J. Grenet, M. Monnet and C. van Effenterre (2021): "Do Female Role Models Reduce the Gender Gap in Science? Evidence from French High Schools", *HALSHS*, no 713068v5, evaluate the causal effect of a programme of the L'Oréal Foundation that aims to present careers in science. The programme greatly increases the propensity of female high school students to apply to preparatory classes for the *grandes* écoles of engineering: among female high school students in the top quartile of mathematics performance, the fraction applying to preparatory classes increases from 25 to 38%.

[32] Indeed, the annual productivity growth rate would increase from 0.90% (*status quo*, row 1 of Table 1) to 1.07% (row 2), an increase in annual growth of 0.17 percentage points. In the case of full awareness of all women in science and innovation careers, productivity growth would be 1.54% (row 3).

[33] See the associated *Focus*, Feng *et al.* (2022, *op. cit*).

Secondly, the participation of companies in this strategy should be promoted, for example with tax incentives for employee hours (specialised in innovation or research) spent mentoring or coaching young trainees.

Thirdly, several existing initiatives should be strengthened and disseminated on a national scale in the short term. For example, awareness of innovation should be integrated into programmes to bring schools and companies closer together and, more generally, into career guidance, especially at secondary school level for students who have opted for scientific specialities. Another example would be to strengthen the "1 scientifique, 1 classe: *chiche*!" programme of the French National Institute for Research in Computer Science and Control (INRIA), which enables pupils in the second year of secondary school to meet researchers in the digital sciences, particularly from INRIA.

Fourth, initiatives with high media visibility could be launched in the short term to use the media as a relay for the national strategy of innovation by all. For example, 100 CEOs of major French startups, including unicorns, could commit to organising mentoring and internships for young people from disadvantaged areas to introduce them to entrepreneurship and innovation. Similarly, 100 leading French scientists could commit to offering mentoring and internships to young people from disadvantaged neighbourhoods to introduce them to science and research. Finally, ten partnerships with major innovation and research institutions in France for summer programmes dedicated to disadvantaged groups could be set up, for example at Station F, the iPEPS Campus, in the laboratories of major universities, or at the *Conservatoire national des arts et métiers* (CNAM).

Eventually, the national strategy for innovation by all should be integrated into the guidance policy of the national education system. The above-mentioned measures should all be mobilised in concert and should be targeted primarily at girls and pupils in the high priority education network, which represents 250 000 young people. The national strategy for innovation by all should be guided by ambitious long-term objectives, such as achieving parity and territorial equality in science courses, particularly in the *grandes écoles* of engineering and their preparatory classes, within ten years.[34]

Recommendation 3. Create a "national strategy for innovation by all" to raise awareness of careers in innovation and science among all young people, with a budget of 100 million euros per year to fund complementary initiatives (information workshops, mentoring, internships, immersions, forums, innovation competitions).

Optimising innovation grants

Finally, we analyse how to optimise innovation subsidies to increase productivity.

Companies perceive few difficulties in accessing finance

Financing for business is a traditional public policy lever that seems to have borne fruit. BPI survey data suggest that access to finance is no longer a major barrier to investment by French companies.[35] It therefore seems unnecessary to devote additional public resources to business financing. This conclusion must be tempered for venture capital, which poses specific financing problems, and in the event of an economic downturn which may require a specific action.

Increasing the effectiveness of the research tax credit

The scientific literature, various evaluation reports and our own analyses show that the Research Tax Credit (*Crédit d'impôt recherche* CIR) is an important but poorly targeted scheme.[36] Unlike its German and British equivalents, the CIR disproportionately benefits large companies. It is not sufficiently focused on small and medium-sized enterprises, which are the most innovative and for which the return on the CIR is the highest according to our estimates.

Based on individual company data (FARE), matched with CIR data, as well as global patent filing data (PATSTAT), we estimate that one million euros directed to small and medium-sized enterprises is associated with a filing of

[34] A recent study shows that, for equal academic performance, Parisian students are three times more like to enter the "grandes écoles". The authors document that the under-representation of girls in the "grandes écoles" is largely determined by their lower propensity to pursue studies in scientific preparatory classes. Bonneau C., P. Charousset, J. Grenet and G. Thebault (2021): "Quelle démocratisation des grandes écoles depuis le milieu des années 2000", *IPP Report*, no 30, January.

[35] *75th SME-IPB business survey*, Le Lab, July 2022.

[36] Bach L., A. Bozio, A. Guillouzouic and C. Malgouyres (2021): *Les impacts du crédit impôt recherche sur la performance économique des entreprises*, Report by the Institut des Politiques Publiques.

1.16 patents, controlling for industry type and years, compared with 0.46 when the same million euros is directed to large companies, i.e. a return 2.5 times higher (Aghion *et al.* 2022).[37] This negative relationship between the return on the CIR and the size of the company is accentuated when the quality of the innovation is taken into account. This can be measured, for example, by the number of triadic patents protecting an invention in Europe, the United States and Japan: the return on the CIR is then more than four times higher for very small firms than for large firms. This estimate is consistent with the evaluation of the *Commission nationale d'évaluation des politiques d'innovation* (CNEPI)[38] and with the economic literature (Baumol, 2002; Rosen, 1991; Akcigit and Kerr, 2018).[39]

The tax credit rate is 30% for expenditure below €100 million and 5% above this threshold. To be fully effective, the CIR should subsidise expenditure that would not otherwise have taken place. This is not the case however for large firms which R&D expenditures typically exceed 100 million euros: they are subsidised at 30% for investments that would have taken place anyway and then at a very low rate of 5% for any additional investment. Larges companies benefit as a result from 400 million in the form of a 5% subsidy, the incentive effect of which on R&D spending is weak.

The creation of the CIR was intended in particular to compensate for the difference in corporate income tax (CIT) and production taxes between France and its neighbours, which is important in particular for the location choices of large groups. Due to recent reforms of corporate and production taxes, this objective must now be questioned. For example, the production taxes paid by large companies that are also beneficiaries of the CIR have almost been halved, falling from around €3 billions per year in the early 2010s to around €1.5 billion in 2017-2018. Production taxes have also been reduced again in 2020, with the reduction by half of the business value added tax (CVAE, which should disappear completely from 2023), as well as the reduction by half of the business property tax (CFE) and the property tax on built-up areas (TFPB). Finally, the corporation tax has been gradually reduced from 33% in 2017 to 25% in 2022, while it has been increasing in the UK and the US.

Finding 4. The incentive effect of the CIR is weak for the R&D expenditure of large groups, which benefit from 400 millions euros of subsidies at 5%. The need for the CIR to maintain cost competitiveness must be questioned because of the drop in production taxes and corporate tax.

2. Summary of macroeconomic issues

Economic phenomenon studied	Macroeconomic effect	Source
Productivity slowdown in France compared to Germany and the US between 2004 and 2019	PGDP shortfall of about 140 billion after 15 years	Analyse de la productivité du travail ajusté des effets de composition
Potential impact of a "PISA shock" leading to an increase in educational attainment (mathematics, soft skills)	0.2 percentage point of GDP growth per year, i.e. an annual gain of around 75 billion after 15 years	Extension des travaux empiriques de Hanushek sur l'impact du niveau cognitif sur le PIB par habitant ; *Focus* Martin *et al.* (2022) et *Focus* Guadalupe et Ng (2022)
Potential impact of the implementation of a national innovation strategy by all	0.2 percentage point of GDP growth per year, i.e. an annual gain of around 75 billion after 15 years	Modèle développé par Feng *et al.* (2022)

Sources: Martin R., T. Renault and B. Roux (2022): "Baisse de la productivité en France : échec en 'maths' ?", *Focus du CAE*, no 091-2022, September; Guadalupe M. and B. Ng (2022): "Soft Skills and Productivity in France", *Focus du CAE,* no 092-2022, September; Feng J., X. Jaravel and É. Richard (2022): "Pour une stratégie nationale d'innovation par tous", *Focus du CAE*, no 089-2022, September.

[37] Aghion P., N. Chanut and X. Jaravel (2022): "Réformer le Crédit d'impôt recherche", *Focus du CAE*, no 90-2022, September.

[38] CNEPI (2021): *Evaluation of the Research Tax Credit,* Report.

[39] Baumol W.J. (2002): "Entrepreneurship, Innovation and Growth: The David-Goliath Symbiosis", *Journal of Entrepreneurial* Finance *(JEF)*, vol. 7, no 2, pp. 1-10; Rosen R.J. (1991): "Research and Development with Asymmetric Firm Sizes", *The RAND Journal of Economics*, vol. 22, no 3, pp. 411-429; Akcigit U. and W.R. Kerr (2018): "Growth through Heterogeneous Innovations", *Journal of Political Economy*, vol. 126, no 4, pp. 1374-1443.

To optimise the CIR and increase its effectiveness, we propose to abolish the reduced subsidy rate of 5%. In addition, we propose to lower the ceiling of eligible expenses for the standard rate from 100 million to 20 million euros. By keeping the overall financial envelope of the CIR constant, this change would allow the standard rate to be increased below the ceiling. Our estimates show that it would be possible to substantially increase the subsidy rate (from 30% to 42%) for all CIR beneficiaries below the ceiling. This would make it possible to increase innovation and productivity because, empirically, the effect of the CIR is higher for small and medium-sized enterprises, which would benefit from a higher rate in the optimised CIR scheme.[40]

The CIR reform scenarios we have studied do not call into question tax stability and send a favourable signal in favour of innovation and the efficiency of public spending.[41] It is also possible to imagine a scenario where the additional revenue generated by a lowering of the ceiling would be used to reduce other taxes or production taxes, such as the social solidarity contribution for companies (C3S), the abolition of which would benefit large companies in particular and have a positive impact on productivity.[42]

Recommendation 4. To strengthen the impact of the CIR, lower the ceiling on eligible expenditure to 20 million and increase the subsidy rate from 30% to 42%.

Conclusion

Human capital is a lever for accelerating productivity that must become a national priority: the macroeconomic stakes are high (*see* Table 2) and justify the implementation of new, ambitious and sustainable strategies. This means, on the one hand, reforming the education system to promote the acquisition of mathematical and soft skills and, on the other hand, democratising access to careers in science and innovation.

[40] 2% of large groups –which currently receive the CIR for more than 20 million euros of eligible expenditure– would be disadvantaged by this reform. All other companies would benefit and the system as a whole would be more efficient.

[41] Three arguments are generally put forward by critics of a reform of the CIR, namely that a reform would be detrimental to fiscal stability, would send an unfavourable signal for the support of innovation and could constitute a legal risk on State aid if the European Commission examines the new system. The scenarios studied respond in advance to these criticisms because the CIR is not abolished but simply redeployed (taking into account other recent changes in taxation in France with regard to corporate income tax and production taxes); the signal sent to innovation is positive because the system is redeployed to maximise support for innovation; the system after the reform would be closer to the tax aid for R&D in Germany, which has not raised any opposition from the European Commission

[42] See Martin P. and A. Trannoy (2019): "Taxes on Production: The Good, the Bad and the Ugly", *Note du CAE*, no 53, October.

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