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The Economic Benefits of Improving Educational Achievement in the European Union: An Update and Extension

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The Results at a Glance

This report quantifies the economic benefits of educational improvement for each of the EU countries. The analysis focuses on the relationship between educational achievement (as measured by the Programme for International Student Assessment (PISA)) and the long-run growth of nations. Building on prior research that shows the strong historical relationship of growth and educational achievement, it projects the aggregate economic results of improvements in achievement.

The projections incorporate the dynamics of educational reform – that it takes time for student improvements to appear and for better-skilled workers to become a noticeable proportion of the workforce. We model four educational improvement scenarios.

The **first** scenario considers an **increase in student achievement** of 25 PISA points. This reform, shown possible by several EU countries, would add €71 trillion to EU GDP over the status quo. This amounts to an aggregate EU gain of almost 3½ times current levels of GDP and an <u>average GDP that is seven percent higher</u> for the remainder of the century.

The **second** scenario brings **all low-performing students up to basic skill requirements** for competing in today's economy (PISA level 2). Achieving this goal would <u>boost average GDP</u> over the 21st Century <u>by nearly four percent</u>. The more limited goal of the Strategic Framework for European cooperation in education and training (ET 2020) to reduce low achievement to 15 percent by country would have only about one-seventh the impact.

The **third** scenario matches the goal of ET 2020 calling for **reductions in early school leaving**. Enhancing the skills of all potential early school leavers is projected to <u>raise average GDP by 0.7 percent</u>. Just reaching the specific ET 2020 goal of no more than 10 percent early leavers in each EU country has significantly less impact (0.1 percent).

The **fourth** scenario focuses on **top performers**, ensuring that at least 15 percent of students in each country achieve PISA level 5. While having minimal effect on currently high-achieving countries, <u>average GDP across EU countries would be 0.5 percent higher</u> over the remainder of the century.

This analysis highlights the large impacts of educational reforms on EU Member States, in particular if they reach substantial portions of the student population. Implementing successful reforms now would strongly benefit the economic well-being of EU Member States.

Executive Summary

Few people doubt that education is valuable for individuals and that a well-educated society benefits each country. But many do not fully understand the magnitude of impact of high-quality education on economic wellbeing. This report provides an analysis of the economic benefits of educational improvement for each of the EU countries.

The analysis focuses on the relationship between educational achievement (as measured by scores on the Programme for International Student Assessment (PISA)) and the long-run growth of nations. Prior research shows that test scores serve as a good proxy for the skills of a nation's workforce and that three-quarters of the variation in long-run growth rates across countries can be attributed to these quantitative measures of educational outcomes.

Using the historical relationship of growth and educational achievement, it is possible to project the aggregate economic results of improvements in achievement. We consider a range of possible changes that implicitly reflect more or less ambitious reform programmes. As is obvious, broad-based reforms have larger economic impacts compared to reforms affecting relatively small portions of the student population.

The projections incorporate the dynamics of educational reform – that it takes time to adjust educational policies and programmes, that student outcomes take added time to appear, and that the economy will only adjust when the new, highly-skilled workers become a noticeable proportion of the workforce. These dynamics imply that the economic gains of improvement take some time to be realised.

To allow for the timing of growth effects, all estimates are calculated in present value terms that give today's monetary equivalent of future economic gains across the remainder of the century. In doing this, gains in the near term are weighted more heavily than gains later on using a three percent discount rate.

Table 1 summarises the results of projections of four educational improvement scenarios. The first scenario considers an increase in student achievement of 25 points on the PISA scale (one-quarter of a standard deviation). While challenging, Portugal, Poland, and Germany have already demonstrated that such gains are feasible. If all EU countries met this goal within 15 years, the aggregate impact on the EU would be faster economic growth (by 0.5 percent annually) in the long run, and this would add GDP over the status quo of €71 trillion. This amounts to an aggregate EU gain of almost 3½ times current levels of GDP and an average GDP that is seven percent higher for the remainder of the century. (The report presents individual country results for these aggregate outcomes).

The other scenarios reflect varying policy approaches. The second scenario brings all low-performing students up to the basic skill requirements for competing in today's economy (taken to be level 2 on the PISA tests). Achieving this goal would boost average GDP over the 21st Century by nearly four percent with countries facing more low-skilled students obtaining proportionately larger improvements in their future economic outcomes. A policy that would not bring all students up to basic skills, but only reduce low achievement to 15 percent in each country (mirroring the goal of the Strategic Framework for European cooperation in education and training – ET 2020), would have only about one-seventh the aggregate impact.

Table 1: The economic benefits of improving educational achievement in the European Union

Policy scenarios	Present value of reform (bn €)	In % of current GDP	In % of discounted future GDP
1. Increasing average performance (25 points)	71 027	340%	7.3%
2. Achieving universal basic skills	37 898	188%	3.9%
At most 15 percent low achievers	*5 223*	*25%*	*0.5%*
3. Enhancing skills of early school leavers	7 097	34%	0.7%
At most 10 percent early leavers	*1 144*	*6%*	*0.1%*
4. Increasing top performance	4 615	22%	0.5%

Notes: Present value of future increases in GDP of EU 28 countries until 2100 due to respective reforms, expressed in billion Euro (PPP), as a percentage of current GDP, and as a percentage of discounted future GDP. See text for reform parameters.

The third scenario matches the goal of ET 2020 calling for a reduction in early school leaving to no more than 10 percent in each EU country. Enhancing the skills of all potential early school leavers is projected to raise average GDP by 0.7 percent, while just reaching the 10 percent benchmark would have considerably less impact (0.1 percent) since only 11 Member States currently have more than 10 percent early school leavers.

The fourth scenario considers expanding the top end of the performance distribution. It ensures that at least 15 percent of students in each country achieve level 5 on the PISA test. While this takes limited adjustment for the top-performing countries, it represents a substantial increase in EU countries that are starting at a performance deficit. In aggregate, average GDP would be 0.5 percent higher over the remainder of the century.

This analysis emphasises the aggregate impacts of educational reform on each of the Member States. There are parallel improvements in the economic wellbeing of individuals who get more skills from the educational system, although these are not the focus of this analysis. Moreover, if economic growth accelerates, these individual rewards are likely to increase.

The simple fact is that skills of the population are extremely important now, and are likely to become more important in the future. Without investments now, current youth are left out of the rewards, and the future economic benefits are postponed and lessened.

Aperçu des principaux résultats

Le présent rapport quantifie les bienfaits économiques de l'amélioration de l'éducation pour chacun des États membres de l'UE. L'analyse se concentre sur le rapport existant entre le niveau d'éducation (mesuré selon les critères prévus par le Programme international pour le suivi des acquis des élèves (PISA)) et la croissance sur le long terme des pays. Se fondant sur des recherches antérieures ayant mis en évidence le fort rapport historique existant entre la croissance et le niveau d'éducation, le présent rapport se donne pour objectif de faire des projections des résultats économiques agrégés liés à l'amélioration du niveau d'éducation.

Les projections intègrent les dynamiques de la réforme de l'éducation, à savoir qu'il faut du temps pour que l'amélioration du niveau des étudiants devienne visible et pour que les travailleurs plus qualifiés deviennent une proportion notable de la main-d'œuvre. Nous avons modélisé quatre scénarios d'amélioration du niveau de l'éducation.

Le **premier** scénario envisage une **amélioration du niveau des étudiants** de 25 points PISA. Cette réforme, indiquée comme possible par plusieurs pays de l'UE, impliquerait une hausse de 71 000 milliards € du PIB de l'UE par rapport au statu quo actuel. Ceci représenterait un gain agrégé pour l'UE de presque 3½ fois les niveaux actuels du PIB, ainsi qu'un PIB moyen 7% plus élevé pour le reste du siècle.

Le **deuxième** scénario vise à amener **l'ensemble des étudiants enregistrant des mauvais résultats au niveau des compétences de base nécessaires** pour prendre part à l'économie actuelle (niveau 2 PISA). La réalisation de cet objectif stimulerait le PIB moyen durant le 21ème siècle à hauteur de presque 4%. L'objectif plus limité du Cadre stratégique pour la coopération européenne dans le domaine de l'éducation et de la formation (ET 2020) visant à réduire la maîtrise insuffisante des acquis fondamentaux à 15 % par pays ne produirait qu'environ un septième de cet impact.

Le **troisième** scénario correspond à l'objectif d'ET 2020 qui préconise la **réduction du taux de décrochage scolaire**. L'amélioration des compétences de l'ensemble des potentiels décrocheurs scolaires augmenterait le PIB moyen de 0,7 %. Le simple fait d'atteindre l'objectif spécifique d'ET 2020 consistant à ne pas dépasser 10 % de décrocheurs scolaires dans chaque pays de l'UE aurait bien moins d'impact (0,1 %).

Le **quatrième** scénario se concentre sur les **étudiants les plus performants**, assurant qu'au moins 15 % des étudiants de chaque pays atteignent le niveau 5 PISA. Bien qu'ayant un effet minime sur les pays déjà très performants, le PIB moyen, tous pays de l'UE confondus, serait, pour ce scénario, 0,5 % plus élevé pour le reste du siècle.

Cette analyse souligne les impacts importants des réformes de l'éducation sur les États membres, notamment si celles-ci touchent des portions substantielles de la population étudiante. La mise en œuvre de réformes réussies à l'heure actuelle profiterait énormément au bien-être économique des États membres de l'UE.

Résumé analytique

Peu sont ceux qui doutent de la valeur de l'éducation pour les individus et du fait qu'une société bien instruite profite à chaque pays. Mais nombreux sont ceux qui ne comprennent pas pleinement l'ampleur de l'impact d'une éducation de haute qualité sur le bien-être économique. Le présent rapport fournit une analyse des bienfaits économiques de l'amélioration du niveau de l'éducation pour chacun des pays de l'UE.

L'analyse se concentre sur le rapport existant entre le niveau d'éducation (mesuré selon les critères prévus par le Programme international pour le suivi des acquis des élèves (PISA)) et la croissance des pays sur le long terme. Des recherches antérieures ont mis en évidence que les résultats des tests constituent un bon indicateur des compétences de la main-d'œuvre d'un pays, et que trois-quarts des variations des taux de croissance des pays sur le long terme, peuvent être imputés à ces mesures quantitatives des résultats en matière d'éducation.

S'appuyant sur le rapport historique existant entre la croissance et le niveau de l'éducation, il s'avère possible de faire des projections des résultats économiques agrégés liés à l'amélioration du niveau d'éducation. Nous avons tenu compte d'une série de changements possibles reflétant implicitement des programmes de réformes plus ou moins ambitieux. Il est évident que les réformes générales ont des retombées économiques plus importantes que les réformes qui n'affectent que des portions relativement restreintes de la population étudiante.

Les projections intègrent les dynamiques de réforme de l'éducation - il faut du temps pour ajuster les politiques et les programmes en matière d'éducation et pour que les résultats des étudiants deviennent visibles ; de plus, l'économie réagira dans le temps au fur et à mesure que les nouveaux travailleurs hautement qualifiés finiront par représenter une proportion notable de la population active. Ces dynamiques impliquent d'attendre un certain temps avant que bénéfices économiques découlant de l'amélioration soient visibles.

Pour tenir compte de délais afférents aux effets sur la croissance, toutes les estimations ont été calculées selon des termes de valeur actuelle, ce qui donne l'équivalent monétaire actuel des gains économiques futurs pour le reste du siècle. De ce fait, les gains à court terme sont pondérés plus fortement que les gains ultérieurs, en utilisant un taux d'actualisation de 3 %.

Le tableau1 résume les résultats des projections pour les quatre scénarios d'amélioration de l'éducation. Le premier scénario envisage une augmentation du niveau éducatif des étudiants de 25 points sur l'échelle PISA (un-quart d'écart type). Malgré des difficultés, le Portugal, la Pologne et l'Allemagne ont d'ores et déjà démontré que de tels gains étaient envisageables. Si tous les pays de l'UE atteignaient cet objectif d'ici 15 ans, l'impact agrégé sur l'Union européenne se traduirait par une croissance économique plus rapide (de 0,5 % par an) sur le long terme, ce qui viendrait ajouter 71 000 milliards € au PIB par rapport au statu quo. Ceci représenterait un gain agrégé pour l'UE de presque 3½ fois les niveaux actuels du PIB, ainsi qu'un PIB moyen 7% plus élevé pour le reste du siècle. (Le rapport détaille les résultats par pays pour ces résultats agrégés).

Tableau 1 : Les bienfaits économiques de l'amélioration du niveau de l'éducation dans l'Union européenne

Scénarios politiques	Valeur actuelle de la réforme (milliards €)	En % du PIB actuel	En % du PIB actualisé futur
1. Amélioration du niveau moyen (25 points)	71 027	340 %	7,3 %
2. Objectif des compétences de base universelles atteint	37 898	188 %	3,9 %
Au plus 15 % d'étudiants au niveau minimal de compétences	*5223*	*25 %*	*0,5 %*
3. Amélioration des compétences des décrocheurs scolaires	7097	34 %	0,7 %
Au plus 10 % des décrocheurs précoces	*1144*	*6 %*	*0,1 %*
4. Amélioration des performances maximales	4615	22 %	0,5 %

À noter : Valeur actuelle des futures augmentations du PIB dans les 28 pays de l'UE jusqu'en 2100, en fonction des réformes respectives, exprimée en milliards d'euros (PPA[1]), en tant que pourcentage du PIB actuel et en tant que pourcentage du PIB actualisé futur. Voir texte pour en savoir plus sur les paramètres des réformes.

Les autres scénarios reflètent différentes approches politiques. Le deuxième scénario consiste à amener tous les étudiants enregistrant des mauvais résultats à un niveau minimum de compétences pour prendre part à l'économie actuelle (le niveau 2 dans les tests PISA). La réalisation de cet objectif stimulerait le PIB moyen durant le 21ème siècle à hauteur de presque 4 %, les pays avec davantage d'étudiants peu compétents obtenant des améliorations proportionnellement plus importantes de leurs résultats économiques futurs. Une politique qui n'amènerait pas tous les étudiants à atteindre les compétences de base mais qui se limiterait à réduire l'échec scolaire à 15 % dans chaque pays (à l'instar de l'objectif du Cadre stratégique pour la coopération européenne dans le domaine de l'éducation et de la formation (ET 2020)) aurait un impact agrégé environ 7 fois plus faible.

Le troisième scénario correspond à l'objectif d'ET 2020 qui préconise une réduction du décrochage scolaire à 10 % dans chacun des pays de l'UE. L'amélioration des compétences de tous les décrocheurs scolaires potentiels devrait permettre d'augmenter le PIB moyen de 0,7 %, tandis que se limiter à atteindre le seuil de 10 % produirait un impact bien moins considérable (0,1 %) puisque seulement 11 États membres de l'UE enregistrent actuellement un décrochage scolaire de plus de 10 %.

Le quatrième scénario envisage l'expansion du niveau de performance maximal, assurant qu'au moins 15 % des étudiants de chaque pays atteignent le niveau 5 du test PISA. Si cela implique un ajustement limité pour les pays les plus performants, un tel projet représente une augmentation substantielle du nombre de pays de l'UE en déficit de performance. En valeur agrégée, le PIB moyen serait alors plus élevé de 0,5 pour le reste du siècle.

Cette analyse met l'accent sur les impacts agrégés de la réforme de l'éducation sur chacun des États membres de l'UE. Il existe des améliorations parallèles du bien-être économique des individus qui acquièrent davantage de compétences en fonction du système éducatif, mais ce n'est pas l'objet de la présente analyse. En outre, si la croissance économique s'accélère, ces avantages individuels vont certainement augmenter.

En fait, les compétences de la population sont extrêmement importantes à l'heure actuelle, et elles le deviendront très probablement encore davantage à l'avenir. À défaut d'investissements aujourd'hui, la jeunesse actuelle ne sera pas récompensée et les bienfaits économiques risquent d'être différés et moindres.

1 Valeur mesurée en paritéé de pouvoir d'achat (PPA)

Die Ergebnisse auf einen Blick

Der vorliegende Bericht quantifiziert die wirtschaftlichen Erträge verbesserter Bildungsleistungen für alle EU-Staaten. Die Analyse konzentriert sich auf den Zusammenhang zwischen Bildungsleistungen (wie in der internationalen Schulleistungsstudie Programme for International Student Assessment (PISA) gemessen) und dem langfristigen Wachstum von Nationen. Aufbauend auf früheren Untersuchungen, die einen deutlichen historischen Zusammenhang zwischen Wachstum und Bildungsniveau belegen, prognostiziert er die aggregierten wirtschaftlichen Auswirkungen von verbesserten Leistungsniveaus.

Die Prognosen berücksichtigen die Dynamik von Bildungsreformen – dass es Zeit braucht, bis bei Schülern Verbesserungen sichtbar werden und besser ausgebildete Arbeitskräfte einen spürbaren Anteil der Erwerbstätigen ausmachen. Wir modellieren vier Szenarien eines verbesserten Bildungsniveaus.

Das **erste** Szenario betrachtet eine **Erhöhung des Bildungsniveaus von Schülern** um 25 PISA-Punkte. Diese Reform, deren Realisierbarkeit in mehreren EU-Staaten demonstriert wurde, würde das EU-BIP um 71 Billionen Euro im Vergleich zum Status quo erhöhen. Dies entspricht einem aggregierten EU-Ertrag des fast 3½-fachen des aktuellen BIP und einem <u>durchschnittlich sieben Prozent höheren BIP</u> über den Rest des Jahrhunderts.

Das **zweite** Szenario modelliert, dass **alle leistungsschwachen Schüler die grundlegenden Qualifikationsanforderungen,** um in der heutigen Wirtschaft mithalten zu können (PISA-Stufe 2), erreichen. Die Erreichung dieses Ziels würde <u>das durchschnittliche BIP</u> im Laufe des 21. Jahrhunderts <u>um fast vier Prozent steigern</u>. Das begrenztere Ziel des strategischen Rahmens für die europäische Zusammenarbeit auf dem Gebiet der allgemeinen und beruflichen Bildung (ET 2020), den Anteil der leistungsschwachen Schüler auf 15 Prozent pro Land zu verringern, hätte nur etwa ein Siebtel dieses Effekts.

Das **dritte** Szenario entspricht dem Ziel des ET 2020, **die Schulabbrecherquote zu senken**. Eine Verbesserung der Kompetenzen aller potentiellen Schulabbrecher würde <u>das durchschnittliche BIP um 0,7 Prozent erhöhen</u>. Eine bloße Erreichung des ET 2020-Ziels von nicht mehr als 10 Prozent Schulabbrechern in jedem EU-Staat hat deutlich geringere Auswirkungen (0,1 Prozent).

Das **vierte** Szenario konzentriert sich auf **Top-Performer** und modelliert, dass mindestens 15 Prozent der Schüler in jedem Land PISA-Stufe 5 erreichen. Während dies nur einen minimalen Effekt auf aktuell leistungsstarke Länder hat, <u>wäre das durchschnittliche BIP über alle EU-Staaten</u> für den Rest des Jahrhunderts um <u>0,5 Prozent höher</u>.

Diese Analyse verdeutlicht die enormen Auswirkungen von Bildungsreformen auf die EU-Mitgliedstaaten, insbesondere wenn sie einen großen Anteil der Schüler erreichen. Eine zeitnahe Umsetzung erfolgreicher Reformen würde dem wirtschaftlichen Wohlstand der EU-Mitgliedstaaten daher enorm zugutekommen.

Zusammenfassung

Kaum jemand bezweifelt, dass Bildung wertvoll für den Einzelnen ist und dass jedes Land von einer gut ausgebildeten Bevölkerung profitiert. Doch vielen ist nicht vollends bewusst, wie stark sich qualitativ hochwertige Bildung auf das wirtschaftliche Wohlergehen auswirkt. Der vorliegende Bericht liefert eine Analyse der wirtschaftlichen Erträge verbesserter Bildungsleistungen für alle EU-Staaten.

Die Analyse konzentriert sich auf den Zusammenhang zwischen Bildungsleistungen (wie in der internationalen Schulleistungsstudie Programme for International Student Assessment (PISA) gemessen) und dem langfristigen Wachstum von Nationen. Frühere Untersuchungen haben gezeigt, dass Testergebnisse ein guter Indikator für die Kompetenzen der Erwerbstätigen eines Landes sind und dass sich drei Viertel der Unterschiede in den langfristigen Wachstumsraten zwischen den Ländern auf diese quantitativen Messgrößen der Bildungsergebnisse zurückführen lassen.

Nutzt man den historischen Zusammenhang zwischen Wachstum und Bildungsniveau, lassen sich die aggregierten wirtschaftlichen Auswirkungen von verbesserten Leistungsniveaus prognostizieren. Wir betrachten eine Reihe möglicher Veränderungen, die implizit mehr oder weniger ehrgeizige Reformprogramme widerspiegeln. Es ist offensichtlich, dass breit angelegte Reformen größere wirtschaftliche Auswirkungen haben als Reformen, die einen relativ kleinen Anteil der Schüler betreffen.
Die Prognosen berücksichtigen die Dynamik von Bildungsreformen – es braucht Zeit, um Bildungspolitik und -programme anzupassen und die Ergebnisse der Schüler brauchen zusätzliche Zeit, um sichtbar zu werden. Die Wirtschaft wiederum wird sich erst anpassen, wenn die neuen, hochqualifizierten Arbeitskräfte einen spürbaren Anteil der Erwerbstätigen ausmachen. Diese Dynamiken implizieren, dass die wirtschaftlichen Verbesserungen einige Zeit in Anspruch nehmen, um realisiert zu werden.

Um den Zeitablauf der Wachstumseffekte zu berücksichtigen, werden alle Schätzungen auf Grundlage des Barwerts berechnet, der den heutigen monetären Gegenwert künftiger wirtschaftlicher Erträge für den Rest des Jahrhunderts angibt. Dabei werden unter Verwendung eines Abzinsungssatzes von drei Prozent kurzfristige Erträge stärker gewichtet als spätere Erträge.

Tabelle 1 fasst die Ergebnisse der Prognosen von vier Szenarien der Verbesserung des Bildungsniveaus zusammen. Das erste Szenario betrachtet eine Erhöhung des Bildungsniveaus von Schülern um 25 Punkte auf der PISA-Skala (ein Viertel einer Standardabweichung). Portugal, Polen und Deutschland haben bereits bewiesen, dass solche Verbesserungen erzielbar sind, auch wenn sie eine Herausforderung bedeuten. Sollten alle EU-Länder dieses Ziel innerhalb von 15 Jahren erreichen, wäre die Gesamtwirkung auf die EU langfristig ein schnelleres Wirtschaftswachstum (von jährlich 0,5 Prozent), welches das BIP gegenüber dem Status quo um 71 Billionen Euro erhöhen würde. Dies entspricht einem aggregierten EU-Ertrag des fast 3½-fachen des aktuellen BIP und einem um sieben Prozent höheren durchschnittlichen BIP über den Rest des Jahrhunderts. (Der Bericht präsentiert die Resultate der einzelnen Länder für diese aggregierten Ergebnisse.)

Tabelle 1: Die wirtschaftlichen Erträge einer Verbesserung der Bildungsleistungen in der Europäischen Union

Politische Szenarien	Barwert der Reform (Mrd. Euro)	In % des aktuellen BIP	In % des abgezinsten zukünftigen BIP
1. Durchschnittliche Leistung steigern (25 Punkte)	71.027	340 %	7,3 %
2. Universelle Grundkompetenzen erreichen	37.898	188 %	3,9 %
Höchstens 15 Prozent Lernschwache	*5223*	*25 %*	*0,5 %*
3. Kompetenzen von Schulabbrechern erhöhen	7097	34 %	0,7 %
Höchstens 10 Prozent Schulabbrecher	*1144*	*6 %*	*0,1 %*
4. Spitzenleistung steigern	4615	22 %	0,5 %

Anmerkungen: Aktueller Wert zukünftiger BIP-Zunahmen der 28 EU-Länder bis 2100 aufgrund entsprechender Reformen, ausgedrückt in Milliarden Euro (KKP[2]), als Prozentsatz des derzeitigen BIP und als Prozentsatz des diskontierten zukünftigen BIP. Siehe Text für Reformparameter.

Die anderen Szenarien spiegeln unterschiedliche Politikansätze wider. Das zweite Szenario lässt alle leistungsschwachen Schüler die grundlegenden Qualifikationsanforderungen erreichen, um in der heutigen Wirtschaft mithalten zu können (gemessen als Stufe 2 bei den PISA-Tests). Das Erreichen dieses Ziels würde das durchschnittliche BIP im Laufe des 21. Jahrhunderts um fast vier Prozent steigern, wobei Länder mit mehr kompetenzschwachen Schülern proportional größere Verbesserungen in ihrer zukünftigen wirtschaftlichen Entwicklung erzielen. Eine Politik, die nicht alle Schüler auf ein Grundkompetenzniveau bringt, sondern lediglich die Leistungsschwäche in jedem Land auf 15 Prozent reduziert (gemäß dem Ziel des strategischen Rahmens für die europäische Zusammenarbeit auf dem Gebiet der allgemeinen und beruflichen Bildung – ET 2020), hätte nur etwa ein Siebtel dieses Effekts.

Das dritte Szenario entspricht dem Ziel des ET 2020, die Schulabbrecherquote in jedem EU-Staat auf nicht mehr als 10 Prozent zu senken. Eine Verbesserung der Kompetenzen aller potentiellen Schulabbrecher würde das durchschnittliche BIP um 0,7 Prozent erhöhen, während eine bloße Erreichung des 10-Prozent-Richtwerts bedeutend geringere Auswirkungen hätte (0,1 Prozent), da nur 11 Mitgliedstaaten aktuell mehr als 10 Prozent Schulabbrecher haben.

Das vierte Szenario betrachtet eine Verbesserung am oberen Ende der Leistungsverteilung. Es modelliert, dass mindestens 15 Prozent der Schüler in jedem Land Stufe 5 beim PISA-Test erreichen. Während dies für die leistungsstarken Länder nur eine begrenzte Anpassung erfordert, stellt es in EU-Staaten, die mit einem Leistungsdefizit starten, eine beträchtliche Erhöhung dar. Insgesamt wäre das durchschnittliche BIP für den Rest des Jahrhunderts um 0,5 Prozent höher.

Diese Analyse betont die Gesamtauswirkungen von Bildungsreformen auf die einzelnen Mitgliedstaaten. Gleichzeitig verbessert sich das wirtschaftliche Wohlergehen Einzelner, die mehr Kompetenzen im Bildungssystem erwerben, obwohl dies nicht der Schwerpunkt dieser Analyse ist. Wenn sich das Wirtschaftswachstum beschleunigt, dürften sich diese individuellen Erträge zudem noch erhöhen.

[2] Kaufkraftparität

Die einfache Tatsache ist, dass Kompetenzen in der Bevölkerung jetzt extrem wichtig sind und in Zukunft wohl noch an Bedeutung gewinnen werden. Werden nun keine Investitionen getätigt, werden die heutigen Jugendlichen von diesen Vorteilen ausgeschlossen, und der zukünftige wirtschaftliche Nutzen wird verschoben und gemindert.

Introduction

The ever-changing conditions of the global economy are raising concerns among citizens about their future prosperity and that of their societies. New challenges are emerging, including technological changes such as automation and digital transformation, shifting trade patterns and increasing tensions in the global economy, political polarisation and rising populism, and increasing concerns about inequality, especially inequality of opportunity. In facing these challenges, the education of the population is a critical component not only for the economic prosperity of individuals and societies but also for social cohesion. Research shows that the educational achievement of students provides the foundation for the skills of the future labour force, and this is a leading determinant of long-term economic growth and future economic wellbeing (Hanushek and Woessmann (2015a)).

In the debate about the future of Europe, the European Commission (2018a) has expressed strong policy interest in strengthening education in Europe. Its Communication "Building a stronger Europe: the role of youth, education and culture policies" emphasises the role of investments in education and training in empowering Europe's citizens to benefit from the potential offered by new global trends and emerging technologies. The fact that European education and finance ministers plan to hold a joint meeting in November 2019 on the importance of investing in people's competences is evidence of the renewed interest in the relationship between investment in education and economic returns in the European Union.

Serious deficiencies are found in the educational achievement of students in the European Union. There of course is substantial variation in how EU Member States perform in terms of the math, science, and reading achievement of their students, and the lack of convergence in average performance points to increasing economic disparities in the future. Overall, the European Union seriously lags behind its own benchmark of reducing the share of low achievers below 15 percent by 2020; in fact, the results of OECD's Programme for International Student Assessment (PISA) in 2015 indicate a step backward compared to the previous PISA wave (European Commission (2016)). The share of 15-year-olds who fail to reach PISA level 2 has increased to 20-22 percent in the three domains. These low achievers lack the most basic skills necessary to participate in modern societies.

This report quantifies the potential consequences of this underachievement for the future prosperity of the European Union and its constituent states. As a quantification of the economic rationale for investing in education and raising standards of educational achievement, it provides up-to-date estimates of how much the European Union would gain, in economic terms, from educational reforms that improve student achievement. Based on the observed historical relationship between educational achievement and GDP growth, it projects the future evolution of GDP with improved educational achievement of varying magnitudes. The GDP difference between a projection with the status quo and that with improved educational outcomes provides an estimate of the economic benefits of improved educational achievement. Building on the methods employed in the OECD report "Universal Basic Skills" (Hanushek and Woessmann (2015b)), we update earlier calculations of the cost of low educational achievement in the European Union to the most recently available economic and educational data.[3] Using estimates of Member States' gross domestic product (GDP) in 2020 and student achievement in the 2015 PISA test, we

[3] The OECD projections use both earlier economic data and prior test score information for EU countries. They build on Hanushek and Woessmann (2010a, 2012b).

provide projections of the economic benefits of improving educational achievement in the European Union over the next 80 years, the expected lifetime of a child born today.

Our projections indicate that insufficient education imparts heavy costs on society and that raising educational achievement will have huge economic benefits for society. We consider alternative scenarios of educational improvement that correspond to current EU policy goals, each of which would be achieved over a period of 15 years.

Under the **first** scenario, each country would **increase** the **average achievement** of its students **by 25 PISA points**.[4] This is a substantial improvement, but one that Portugal, Poland, and Germany managed to achieve in math over the first 15 years of the 21st Century. According to our projections, the total value (in present value terms) of such a reform for the 28 EU countries would amount to over € 70 trillion. This benefit is more than three times the current EU GDP, equivalent to an average increase of 7 percent in the discounted future GDP over the next 80 years. With improving labour forces and commensurately adjusting economies, the annual gains increase over time as increasing shares of better-educated students enter the labour force. Consequently, only about 16 percent of the gains observed over the entire 80-year period accrue over the first 40 years. But by the end of the century, the annual GDP would be 30 percent higher due to the reform.

We also model two scenarios that mirror specific benchmark targets of the European Union. One of the benchmarks under the strategic framework for European policy cooperation in education and training (ET 2020) is that fewer than 15 percent of 15-year-olds should fall short of basic skills (European Commission (2018b)). Under the **second** scenario, **all students** who currently fail to reach level 2 in the OECD's PISA math and science tests are lifted to the **basic skill level** of level 2 (equal to 420 PISA points in math and 410 points in science), which goes substantially beyond the ET 2020 goal. These skills would prepare all students to compete in modern economies and reflect achieving "universal basic skills" (Hanushek and Woessmann (2015b)). The economic benefits of achieving universal basic skills in the EU amount to € 38 trillion. With such gains, the average discounted future GDP increases by 3.9 percent.

The lesser, actual ET 2020 goal of decreasing the share of low-achievers to 15 percent obviously has a significantly smaller impact of € 5 trillion, reflecting the fact that significant shares of students continue to be left behind.

Another ET 2020 benchmark is that the rate of early leavers from education and training aged 18-24 should be below 10 percent. Under the **third** scenario that derives from this goal, we first model a reform that would target **early school leavers** (a share of students of the size equal to the current extent of early school leaving in each country) in a way that ultimately **increases** their achievement **by 25 PISA points**.[5] The economic benefits of this scenario amount to € 7 trillion for the entire European Union.

Unsurprisingly, a more limited reform that assumes a policy closer to the ET 2020 goal where up to 10 percent of a student cohort in each country would not be affected (i.e., only reducing early school leaving to 10 percent) has much lower impacts. Note, however, that only 11 EU countries would be affected by such a reform and very few

[4] Following the underlying model of achievement and GDP growth, all analyses are based on the average achievement in math and science.

[5] Each year of schooling is roughly one-quarter to one-third of a standard deviation or 25 to 33 PISA points (e.g., Woessmann (2016)). Thus, our estimation assumes that school leavers on average get roughly one additional year of schooling under the reform plan.

students would improve. Still, the value of such a limited reform in terms of increased future GDP across the EU would be € 1 trillion.

The **fourth** scenario models **increased performance at the top**. We consider educational improvements that ensure that each country has at least **15 percent at level 5** or above on the PISA test (above 607 PISA points in math and 633 points in science). This policy, designed to ensure a core of scientific and intellectual leadership in each country, has an aggregate impact for the EU of € 4.6 trillion. Again, the smaller aggregate impact of this policy reflects the fact that only a portion of EU countries are significantly affected by this policy goal, as some countries are also close to achieving it.

The calculated aggregate economic benefits of improved educational achievement under the different reform scenarios in terms of gained future GDP growth are truly significant. While not considered here, the enhanced education has commensurate improvements in the economic wellbeing of individuals who now have more skills valued in the labour market (see Hanushek et al. (2015)). Moreover, if economic growth accelerates, these individual rewards are likely to increase (Hanushek et al. (2017)). Assuring solid basic skills for all youth should therefore be a primary policy goal for the countries of the European Union.

As background for the projection analysis, the next section provides an overview of economic research that shows the importance of educational achievement for economic growth. Next, we describe our simulation model and the parameter choices. In the subsequent sections, we report the results on the economic benefits of increasing educational achievement under the different reform scenarios. The final section concludes.

Background: Knowledge Capital and Economic Growth

Education has long been viewed as an important determinant of economic well-being.[6] While early analysis of the role of education emphasised labour market gains to individuals, work over the past quarter century has brought in the implications of education and skills for national economic growth. The theoretical literature on macroeconomic growth emphasises at least three mechanisms through which education may affect economic growth.[7] First, education can be viewed as a component of the labour force and as factor of production that in the aggregate is combined with physical capital to produce a society's GDP. Added human capital for the labour force increases aggregate economic inputs, and the economy would move to a new higher level of output. The economy thus grows as the GDP moves to the higher level implied by increased inputs (as in augmented neoclassical growth theories, e.g., Mankiw, Romer, and Weil (1992)). Second, education can increase the innovative capacity of the economy, and the development of new technologies, products and processes promotes faster growth (as in theories of endogenous growth, e.g., Lucas (1988); Romer (1990); Aghion and Howitt (1998)). Third, education can facilitate the diffusion and transmission of knowledge needed to understand and process new information and to implement successfully new technologies devised by others, which again promotes economic growth (e.g., Nelson and Phelps (1966)).

Following the seminal contributions by Barro (1991) and Mankiw, Romer, and Weil (1992), a vast empirical literature focused on schooling quantity in cross-country growth regressions, with mixed results (see, e.g., Krueger and Lindahl (2001) and Pritchett (2006)

[6] This section draws on Hanushek and Woessmann (2015b, 2019).
[7] See Aghion and Howitt (2009) for a textbook introduction.

for reviews). However, using average years of schooling as an education measure implicitly assumes that a year of schooling delivers the same increase in knowledge and skills regardless of the education system. It also assumes that all skills and human capital come from formal schooling, even though extensive evidence on knowledge development and cognitive skills indicates that a variety of factors outside of school – family, peers, and others – have a direct and powerful influence.

Hanushek and Kimko (2000) first incorporated measures of cognitive skills based on the international tests of student performance preceding PISA into growth analysis and showed that this dramatically alters the assessment of the role of education in economic development. The evidence from an increasing number of studies suggests that the quality of education, measured by the knowledge that students gain as depicted in tests of cognitive skills, is substantially more important for economic growth than the mere quantity of schooling (see Hanushek and Woessmann (2008) for a review).

Our analysis below is based on the empirical growth model previously developed and presented in Hanushek and Woessmann (2015a). In this, an aggregate measure of cognitive skills is developed from international tests of math and science between 1964 and 2003 and scaled like PISA today (see also Hanushek and Woessmann (2016)). This measure of the cognitive skills of a country – which in the aggregate we refer to as the "knowledge capital" of nations – relies on the average standardised test scores from each country's historical participation in the tests, interpreted as a proxy for the average skills of the whole labour force. The growth model combines these skill measures with the average years of school attainment and the initial level of GDP in each country in order to explain the average annual growth rate in real per-capita GDP between 1960-2000 for 50 countries.[8] This estimated growth model, described more formally in Appendix A, forms the basis of our projections of the benefits of improved schooling.

Cognitive skills are strongly associated with economic growth. Once skills are included in the analysis, years of schooling becomes statistically insignificant, and the estimated coefficient drops to close to zero. Furthermore, the variation in cross-country growth explained by the model increases from 25 percent to 73 percent when human capital is measured by cognitive skills rather than years of schooling.

Figure 1 depicts the fundamental association graphically, plotting the long-run growth rates in per-capita GDP against average test scores, after allowing for differences in initial per-capita GDP and average years of schooling. Countries align closely along the regression line that depicts the positive association between cognitive skills and economic growth.

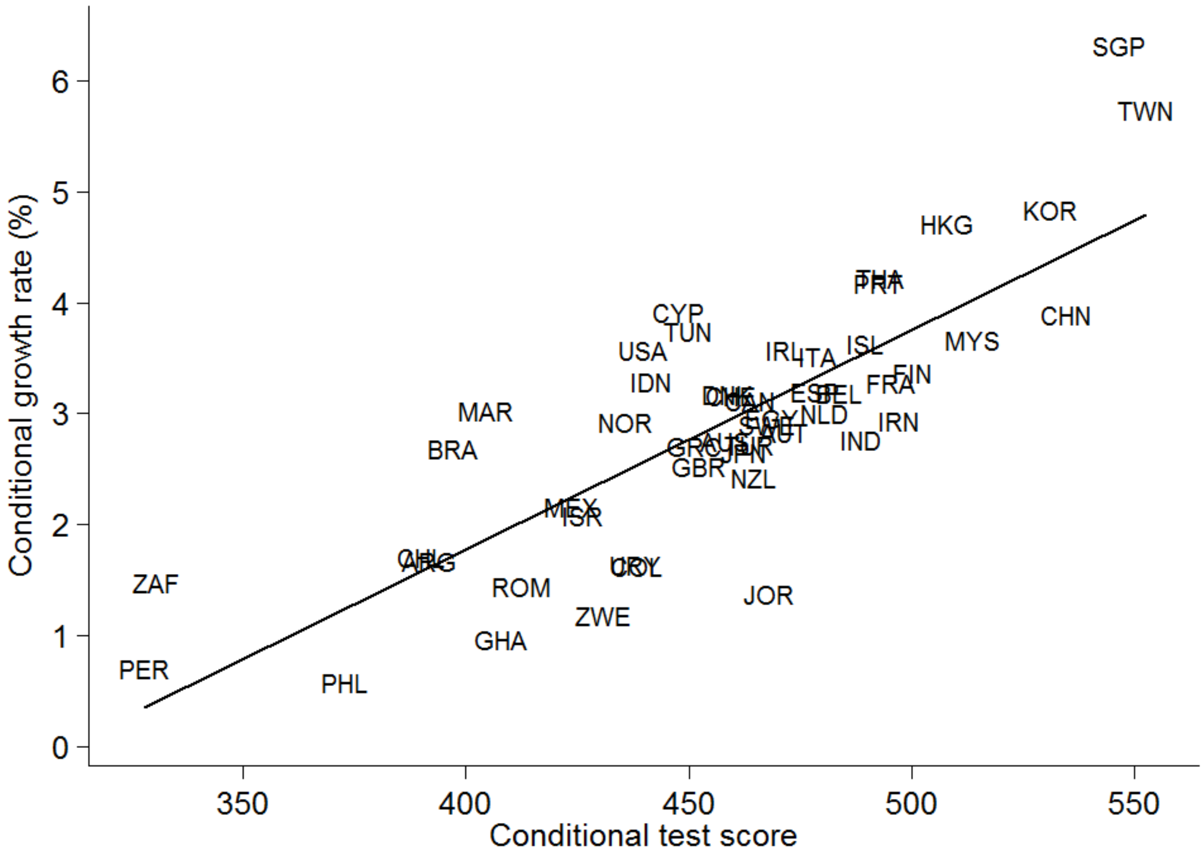
This historical experience suggests a very powerful response to improvements in education outcomes. The estimated coefficient on cognitive skills implies that an increase of one standard deviation in educational achievement (i.e., 100 score points on the PISA scale) yields an average annual growth rate over the 40 years of observation that is 1.98 percentage points higher.

It is, of course, essential to understand whether these estimates can be interpreted as representing a *causal* relationship. If considering basing policies on the results, it is essential that one can reasonably assume that growth rates will improve if student

[8] Initial GDP is included to allow for "catch-up growth," where individual countries that start behind have an opportunity to employ the technologies and production processes introduced by the leading economies. Thus, countries starting behind can growth faster than those who start ahead, because the leaders must invent new, more productive ways to proceed.

achievement is improved. Sophisticated analyses into the underlying causality structure suggest that the estimate can be interpreted as the causal effect of improved cognitive skills on the long-run growth rate of the economy, underscoring the fundamental importance of skills for economic development (see Hanushek and Woessmann (2012a, 2015a)). Although the details of the analysis of causality are beyond the scope of this analysis, Appendix A provides an overview of the underlying analyses. As a consequence of this causality analysis, we believe that it is reasonable to conclude that the basic growth relationship can support a detailed analysis of the economic implications of improving a nation’s knowledge capital.

Figure 1: Knowledge capital and economic growth rates across countries, 1960-2000



Source: Hanushek and Woessmann (2015a); see Appendix A.

Notes: X axis: international student test scores in math and science; Y axis: annual growth rate in per-capita GDP. Added-variable plot of a regression of the average annual rate of growth (in percent) of real GDP per capita in 1960-2000 on average test scores on international student achievement tests, average years of schooling in 1960, and initial level of real GDP per capita in 1960 (mean of unconditional variables added to each axis).

The Simulation Model

Discussions of education policy frequently neglect consideration of the dynamics of educational improvement and of the impact on economic outcomes. Improving schools takes time, and the results of policy changes do not appear instantly. Further, it takes time until the more skilled people coming out of the improved schools have a significant impact on the economy. The projections here are designed to portray the time to improvement and the time to impact more accurately. The important result of this is, however, that the long-run impact of schools on the economic wellbeing of countries comes through strongly. While not instantaneous, the results of school improvement are startlingly large.

We briefly summarise our simulation model here and describe the details in Appendix B. Following the basic setup of the OECD study by Hanushek and Woessmann (2015b), the model uses the estimate of the empirical growth model discussed above to simulate how future growth rates of the economy would develop after an increase in educational achievement (modelled by different reform scenarios). Achievement is measured on the most recent PISA test of 2015.[9]

The base year of the projections is 2020. Their time horizon of the main models is taken as the life expectancy of a child born today, i.e., an 80-year period. We will also report results of shorter projections over a 40-year period.

We project how the GDP of each EU country would develop without and with improved educational achievement. All projected values of future GDP and GDP gains are reported in present value terms (applying a 3 percent discount rate) and are thus directly comparable to the current levels of GDP.

The projections of future GDP trajectories with improved educational achievement after educational reforms rely on a simple description of how skills enter the labour market and have an impact on the economy. As educational reforms cannot improve schools overnight, the analysis assumes that the improvements take 15 years to be fully attained. But of course, the labour force itself will only become more skilled as increasing numbers of new, better-trained people enter the labour market and replace the less-skilled individuals who retire. The analysis assumes that a worker remains in the labour force for 40 years, implying that the labour force will not be made up of fully skilled workers until 55 years have passed (15 years of reform and 40 years of replacing less-skilled workers as they retire).

The growth rate of the economy is calculated each year into the future based on the average skills of workers (which changes as new, more skilled workers enter), multiplied by the historic estimate of how skills affect annual growth. The difference between the projected future GDPs with status-quo skills and those with the improved workforce, i.e., the gain in GDP due to the reform, then provides an estimate of the economic value of the reform, or the economic benefit of improved educational achievement.

In what follows, we provide results of projections of the economic benefits of four different policy reform scenarios. Scenario 1 increases the average achievement of all students. Scenario 2 focuses on improvements among particularly low achievers. Scenario

9 Table C1 in the appendix shows each country's performance on the PISA test, as well as other descriptive statistics on achievement, early school leaving, and GDP.

3 reduces early school leaving. Scenario 4 focuses on improvements among top-performing students.

Scenario 1: The Economic Benefits of Increasing Average Achievement

The first policy scenario considers an improvement of the educational achievement that is obtained on average across all 15-year-old students. The size of the improvement, achieved gradually over a 15-year period (i.e., by 2035), amounts to 25 PISA points, or a quarter of a standard deviation. As a rule of thumb, one-quarter to one-third of a standard deviation is roughly equivalent to what an average student learns during one school year. Accomplishing such an improvement on average across all 15-year-old students is clearly an achievement, but one that Portugal, Poland, and Germany in fact realised in math over comparable periods of time from 2000-2015. A 25-point increase is roughly equivalent to the average achievement difference between the United Kingdom (501) and top-performing Estonia (527), between bottom-performing Cyprus (435) or Romania (439) and Slovakia (468), or between Croatia (470) and Austria or Portugal (496) (see Table C1 in the appendix).

Table 2 shows the results of how this improvement would affect the GDP trajectories of EU countries. The value of the reform for the EU 28 amounts to over € 70 trillion over the 80-year period.[10] Note that this improvement of 25 points has a uniform effect on all countries when viewed relative to their respective GDP. The present value of added GDP would be 340 percent of a country's current GDP, or 7.3 percent higher average GDP over the entire 80 years of the projection. By 2100, GDP would be 30 percent higher than that expected with today's skill levels, representing the result of an annual growth rate that, in the end, is 0.5 percentage points higher.

Of course, the total value of the added GDP differs by the size of the economy (see also Figure 2). For instance, the largest economy, Germany, would see a present value of gains of over € 14 trillion, while smaller countries such as Greece, Hungary, Ireland, and Portugal would see gains just above € 1 trillion.

The analysis of economic effects of education requires a long-run perspective, as impacts will not be evident until the presence of higher-achieving students starts becoming significant in the labour market. Therefore, the baseline projections take an 80-year perspective, the lifetime of a child born today. Initial impacts are very small, and the effects keep increasing over the period. Still, taking a 40-year period, scenario 1 would already yield over € 11 trillion (present value) of added GDP in the EU by 2060 (see Table C2 in the appendix). While reflecting substantial gains, this value over the first half of the entire period is only 16 percent of the ultimate entire gain. But, as should be obvious, getting these future gains requires beginning reforms now. It is not possible to wait until sometime in the future to start and still get these improvements. There will always be a slow initial period while the schools improve and while the future labour force is being developed.

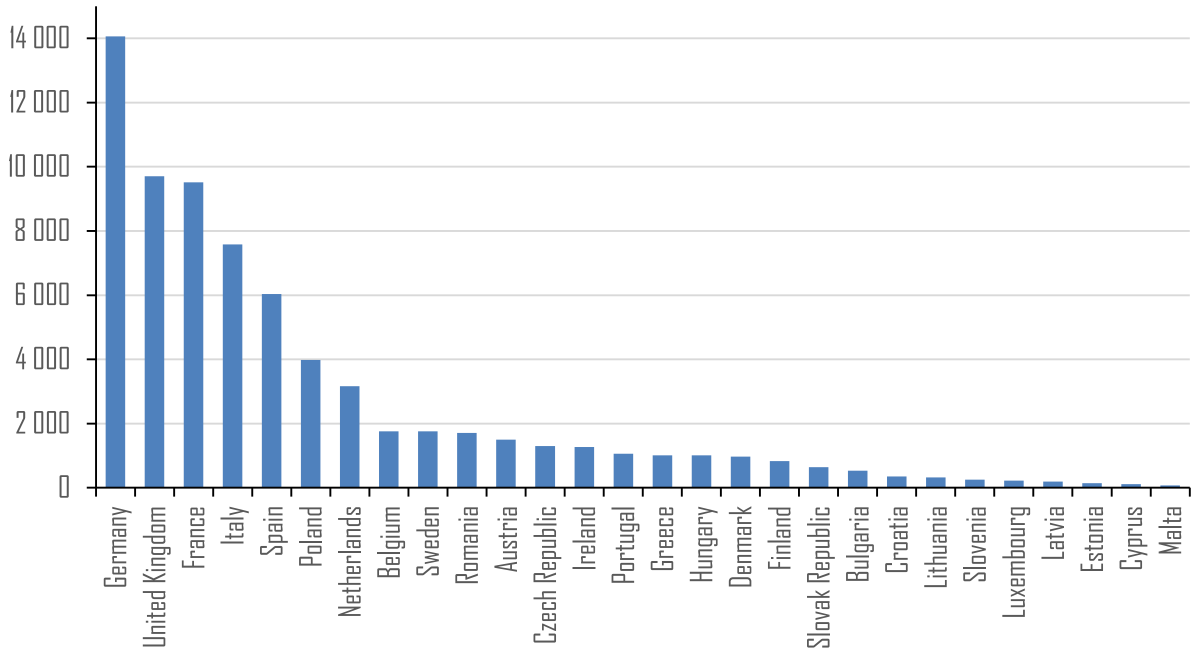
[10] All tables also report aggregate values for the EU 27 without the United Kingdom.

Table 1: Effect on GDP of Scenario 1: Increasing average performance by 25 PISA points

	Value of reform (bn €)	In % of current GDP	In % of discounted future GDP	GDP increase in year 2100	Long-run growth increase	Increase in PISA score
Austria	1 494	340%	7.3%	30%	0.50	25.0
Belgium	1 758	340%	7.3%	30%	0.50	25.0
Bulgaria	535	340%	7.3%	30%	0.50	25.0
Croatia	350	340%	7.3%	30%	0.50	25.0
Cyprus	113	340%	7.3%	30%	0.50	25.0
Czechia	1 300	340%	7.3%	30%	0.50	25.0
Denmark	967	340%	7.3%	30%	0.50	25.0
Estonia	146	340%	7.3%	30%	0.50	25.0
Finland	825	340%	7.3%	30%	0.50	25.0
France	9 511	340%	7.3%	30%	0.50	25.0
Germany	14 064	340%	7.3%	30%	0.50	25.0
Greece	1 014	340%	7.3%	30%	0.50	25.0
Hungary	1 014	340%	7.3%	30%	0.50	25.0
Ireland	1 264	340%	7.3%	30%	0.50	25.0
Italy	7 585	340%	7.3%	30%	0.50	25.0
Latvia	190	340%	7.3%	30%	0.50	25.0
Lithuania	318	340%	7.3%	30%	0.50	25.0
Luxembourg	219	340%	7.3%	30%	0.50	25.0
Malta	70	340%	7.3%	30%	0.50	25.0
Netherlands	3 167	340%	7.3%	30%	0.50	25.0
Poland	3 977	340%	7.3%	30%	0.50	25.0
Portugal	1 055	340%	7.3%	30%	0.50	25.0
Romania	1 704	340%	7.3%	30%	0.50	25.0
Slovakia	641	340%	7.3%	30%	0.50	25.0
Slovenia	251	340%	7.3%	30%	0.50	25.0
Spain	6 035	340%	7.3%	30%	0.50	25.0
Sweden	1 757	340%	7.3%	30%	0.50	25.0
United Kingdom	9 701	340%	7.3%	30%	0.50	25.0
EU 27 (w/o UK)	61 326	340%	7.3%	30%	0.50	25.0
EU 28	71 027	340%	7.3%	30%	0.50	25.0

Notes: Discounted value of future increases in GDP until 2100 due to the reform, expressed in billion Euro (PPP), as a percentage of current GDP, and as a percentage of discounted future GDP. "GDP increase in year 2100" indicates by how much GDP in 2100 is higher due to the reform (in %). "Long-run growth increase" refers to increase in annual growth rate (in percentage points) once the whole labour force has reached higher level of educational achievement. "Increase in PISA score" refers to the ultimate increase in educational achievement due to the reform. See text for reform parameters.

Figure 2: Effect on GDP of Scenario 1: Increasing average performance by 25 PISA points (in billion Euro)



Notes: Discounted value of future increases in GDP until 2100 due to the reform, expressed in billion Euro (PPP). See Table 2 for details.

Scenario 2: The Economic Benefits of Achieving Universal Basic Skills

While the first scenario refers to average achievement levels, the second scenario analyses compensatory policies that target improvement at the bottom of the achievement distribution. Many EU countries still have a very large share of 15-year-olds who are 'low achievers' in basic skills, defined as those who scored below proficiency level 2 on the PISA tests (European Commission (2017b)).[11] This skill level is assumed to represent the minimal skills necessary for participating productively in modern economies. Students who do not reach it will most likely face serious difficulties in their educational career, in the labour market, and in everyday life. Under scenario 2, all children would achieve at least these baseline skills by 2035, making it equivalent to achieving "universal basic skills" (Hanushek and Woessmann (2015b)).

With a policy targeted at a specific subpopulation of students, it is difficult to think of the reform programme precisely reaching just those below level 2 while not affecting anybody already reaching level 2. Almost certainly any realistic policy would also spill over to other students. Thus, while somewhat arbitrary, we assume that some students starting just above the level 2 boundary receive half of the impact that those starting below level 2 received. We allow for this spillover to affect half the number of students directly affected

[11] The OECD (2016) sets level 2 to reaching at least 420 PISA points in math and 410 points in science. The conceptual differences in what students should know at different proficiency levels for mathematics is found in Appendix D.

by the basic compensatory policy in each country – assuming implicitly that the smaller the group needing compensatory policies, the easier it is to target them.

Table 3 presents the projected gains for each country under scenario 2. Aggregated for the entire EU 28, the value of the reform amounts to € 38 trillion. The gained GDP is equivalent to 181 percent of current EU GDP, or 3.9 percent of the discounted GDP over the entire projection period. By the end of the period, annual EU GDP would be 16 percent higher due to the reform.

Table 2: Effect on GDP of Scenario 2: Achieving universal basic skills

	Value of reform (bn €)	In % of current GDP	In % of discounted future GDP	GDP increase in year 2100	Long-run growth increase	Increase in PISA score
Austria	823	187%	4.0%	16%	0.28	14.2
Belgium	923	178%	3.8%	15%	0.27	13.6
Bulgaria	771	489%	10.5%	44%	0.69	34.9
Croatia	253	245%	5.2%	21%	0.36	18.4
Cyprus	165	496%	10.6%	44%	0.70	35.3
Czechia	673	176%	3.8%	15%	0.27	13.4
Denmark	302	106%	2.3%	9%	0.16	8.2
Estonia	26	61%	1.3%	5%	0.09	4.8
Finland	228	94%	2.0%	8%	0.14	7.3
France	6 052	216%	4.6%	19%	0.32	16.3
Germany	5 734	139%	3.0%	12%	0.21	10.7
Greece	1 047	351%	7.5%	31%	0.51	25.7
Hungary	779	261%	5.6%	23%	0.39	19.5
Ireland	398	107%	2.3%	9%	0.16	8.3
Italy	4 587	205%	4.4%	18%	0.31	15.6
Latvia	76	136%	2.9%	12%	0.21	10.5
Lithuania	198	211%	4.5%	18%	0.32	16.0
Luxembourg	147	227%	4.9%	20%	0.34	17.2
Malta	85	408%	8.7%	36%	0.59	29.6
Netherlands	1 327	142%	3.0%	12%	0.22	10.9
Poland	1 427	122%	2.6%	10%	0.19	9.4
Portugal	539	174%	3.7%	15%	0.26	13.3
Romania	1 910	381%	8.1%	34%	0.55	27.8
Slovakia	598	317%	6.8%	28%	0.46	23.4
Slovenia	85	116%	2.5%	10%	0.18	8.9
Spain	2 927	165%	3.5%	14%	0.25	12.6
Sweden	1 001	193%	4.1%	17%	0.29	14.7
United Kingdom	4 818	169%	3.6%	14%	0.26	12.9
EU 27 (w/o UK)	33 080	183%	3.9%	16%	0.32	16.3
EU 28	37 898	181%	3.9%	16%	0.32	16.2

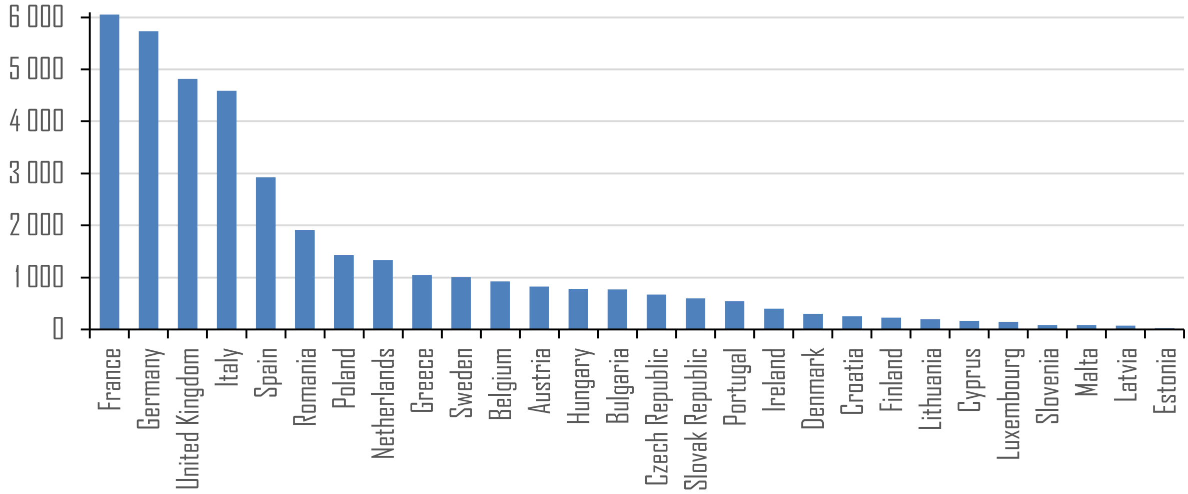
Notes: Discounted value of future increases in GDP until 2100 due to the reform, expressed in billion Euro (PPP), as a percentage of current GDP, and as a percentage of discounted future GDP. "GDP increase in year 2100" indicates by how much GDP in 2100 is higher due to the reform (in %). "Long-run growth increase" refers to increase in annual growth rate (in percentage points) once the whole labour force has reached higher level of educational achievement. "Increase in PISA score" refers to the ultimate increase in educational achievement due to the reform. See text for reform parameters.

For each country, the value of the reform is not just determined by the size of its economy but also by the share of under-achieving students and their distance from the basic-skill level. France and Germany still see the largest present value of gains because of the size of their economies (see Figure 3, panel A). But relative to their current GDP, the largest gains are obtained by currently low-achieving countries. For example, the value of the reform is at least three times the current GDP in Cyprus (where currently 42 percent of students fail to reach level 2), Bulgaria (40 percent), Malta (31 percent), Romania (39 percent), Greece (34 percent), and the Slovakia (29 percent) (see Figure 3, panel B). In these six countries, as well as in Hungary and Croatia, the reform would increase the projected GDP over the entire 80-year period by more than 5 percent on average (see Figure 3, panel C).

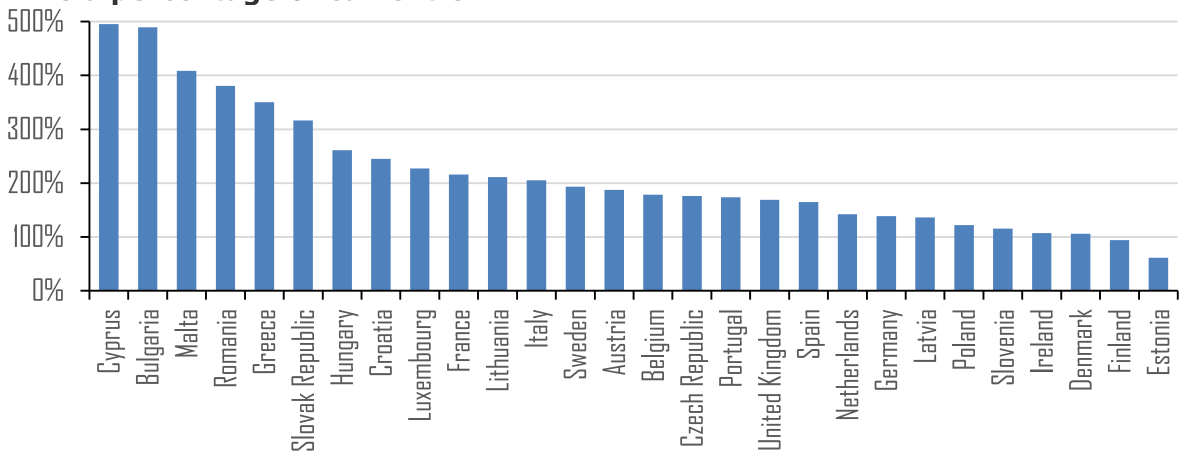
This compensatory policy does go beyond EU goals which call for reducing those without basic skills to less than 15 percent of students (ET 2020 target, European Commission (2018b)). Clearly this more limited policy would have less impact on country economies. We consider a modified compensatory policy that ensures at most 15 percent of students remains below level 2 on a country-by-country basis by 2035. (Note that three countries – Denmark, Estonia, and Finland – currently already have less than 15 percent of their students below level 2, and Ireland and Slovenia have just over 15 percent). Again, feasible policies would undoubtedly spill over both to those just above the level 2 cut-off and to those in the bottom 15 percent. For illustrative purposes, we assume that there are spillovers in the educational improvement to all of the bottom group below the 15th percentile and to a group at the low end of the level 2 students equal to half the size of the low achievers moving above the level 2 boundary. The achievement spillovers are assumed equal to half of the impact on the target population, i.e., they are proportional to the size of the compensatory education reform program. This modified compensatory policy yields gains of € 5 trillion (see Table C3 in the appendix).

Figure 3: Effect on GDP of Scenario 2: Achieving universal basic skills

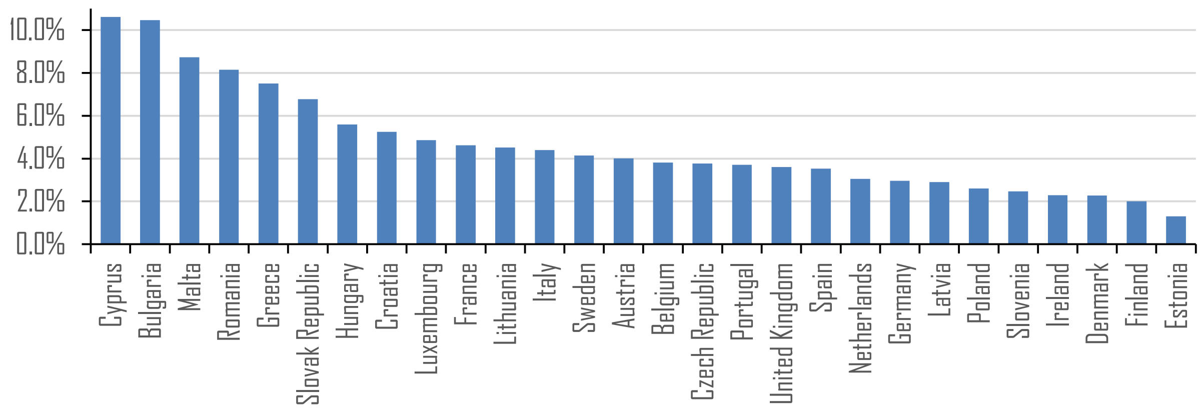
A. In billion Euro (PPP)



B. As a percentage of current GDP



C. As a percentage of discounted future GDP



Notes: Discounted value of future increases in GDP until 2100 due to the reform, expressed in billion Euro (PPP), as a percentage of current GDP, and as a percentage of discounted future GDP. See Table 3 for details.

Scenario 3: The Economic Benefits of Enhancing Skills of Early School Leavers

The third scenario refers to another official EU target, which is to reduce early school leaving. The European Commission (2017a) defines early school leavers as "people aged 18 to 24 fulfilling two conditions: (1) the highest level of education or training they have attained is ISCED 0, 1, or 2 [i.e., do not obtain a certificate of upper secondary education]; (2) they did not receive any education or training in the 4 weeks before the survey." In most countries, school dropout happens only after age 15, when students are tested in PISA.[12]

Scenario 3 models a reform that helps a share of students equal to the current extent of early school leaving in each country, lifting the achievement of these potential early school leavers by 25 PISA points. This projection relates directly to an average increase in schooling for potential school leavers of approximately one year, affecting as many students as the current number of early school leavers and going far beyond the ET 2020 goal.

Table 4 reports the results of the projections under scenario 3. The economic gain from such a reform would amount to € 7 trillion. This is equivalent to about a third of the EU's current GDP, or 0.7 percent of the discounted future GDP over the entire projection period.
In absolute values, the gains are particularly large for large Member States with shares of early school leavers larger than 10 percent – Germany, Spain, the United Kingdom, and Italy – where gains are about € 1 trillion each (see Figure 4, panel A). Relative to GDP, gains are particularly large for the three countries with shares of early school leavers close to 20 percent – Malta, Spain, and Romania (see Figure 4, panel B).

While scenario 3 models improvements for all early school leavers, this overstates the ET 2020 benchmark that is to reduce the share of early school leavers to less than 10 percent. Table C4 in the appendix reports results of a variant of this scenario that would leave up to 10 percent of early school leavers unaffected in each country. Only the 11 EU countries with shares of early school leavers exceeding 10 percent would be affected by this reform at all, and most of them to only a relatively small extent. Accordingly, the value of such a more limited reform would amount to € 1 trillion in the entire EU.

[12] Note that this is different from the scenario "Achieving full participation in secondary school at current quality" in Hanushek and Woessmann (2015b), which was aimed at modelling students who are not enrolled in school at age 14-15 – an issue particularly relevant in many developing countries. The difference is that students can be enrolled at age 15 but not successfully graduate from high school. In fact, in all EU 28 countries except one, the early school leaving rate as measured by the EU is larger than the share of non-enrolled 15-year-olds as measured in the PISA population (OECD (2016), Table A2.1). The one exception is Croatia, which has by far the lowest early-school-leaving share of 2.8 percent according to the EU numbers, but by far the highest (!) share of non-enrolled 15-year-olds among the EU 28 countries of 20.2 percent according to the OECD numbers. This suggests that our estimates of the early-school-leaving scenario for Croatia are likely underestimates that should be taken with considerable caution. In fact, there is no significant correlation between the age-15 enrolment data and the early-school-leaving data across the EU 28 countries. Still, other countries with high non-enrolment shares at age 15 according to the OECD data (Bulgaria, Italy, and Portugal with shares between 8 and 11 percent) also have high shares of early school leavers according to the EU data (around 14 percent each). On the other hand, there are also countries (Malta and Romania) with apparently universal enrolment at age 15 but very high shares of early school leavers (19-20 percent).

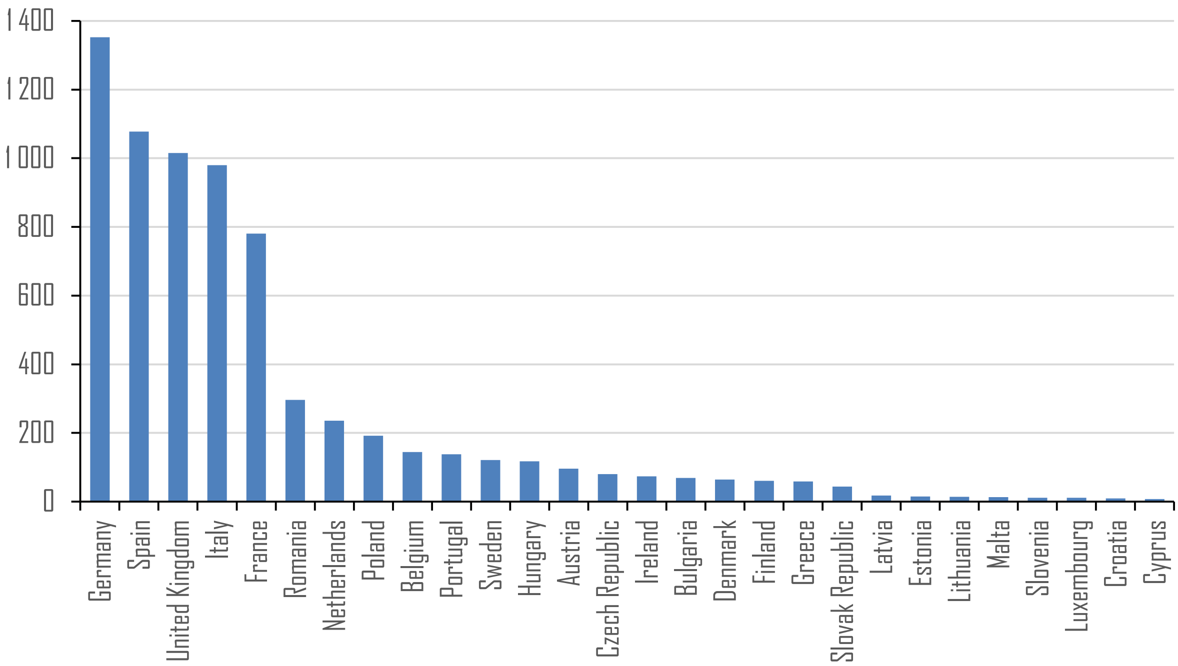
Table 3: Effect on GDP of Scenario 3: Enhancing skills of early school leavers

	Value of reform (bn €)	In % of current GDP	In % of discounted future GDP	GDP increase in year 2100	Long-run growth increase	Increase in PISA score
Austria	96	22%	0.5%	2%	0.03	1.7
Belgium	144	28%	0.6%	2%	0.04	2.2
Bulgaria	69	44%	0.9%	4%	0.07	3.5
Croatia	9	9%	0.2%	1%	0.01	0.7
Cyprus	8	24%	0.5%	2%	0.04	1.9
Czechia	80	21%	0.4%	2%	0.03	1.7
Denmark	65	23%	0.5%	2%	0.04	1.8
Estonia	15	35%	0.7%	3%	0.05	2.7
Finland	61	25%	0.5%	2%	0.04	2.0
France	780	28%	0.6%	2%	0.04	2.2
Germany	1 352	33%	0.7%	3%	0.05	2.6
Greece	59	20%	0.4%	2%	0.03	1.6
Hungary	118	39%	0.8%	3%	0.06	3.1
Ireland	74	20%	0.4%	2%	0.03	1.6
Italy	980	44%	0.9%	4%	0.07	3.5
Latvia	18	32%	0.7%	3%	0.05	2.5
Lithuania	14	15%	0.3%	1%	0.02	1.2
Luxembourg	11	17%	0.4%	1%	0.03	1.4
Malta	13	63%	1.3%	5%	0.10	4.9
Netherlands	236	25%	0.5%	2%	0.04	2.0
Poland	192	16%	0.4%	1%	0.03	1.3
Portugal	138	45%	1.0%	4%	0.07	3.5
Romania	296	59%	1.3%	5%	0.09	4.6
Slovakia	44	23%	0.5%	2%	0.04	1.9
Slovenia	11	15%	0.3%	1%	0.02	1.2
Spain	1 077	61%	1.3%	5%	0.09	4.8
Sweden	121	23%	0.5%	2%	0.04	1.9
United Kingdom	1 015	36%	0.8%	3%	0.06	2.8
EU 27 (w/o UK)	6 082	34%	0.7%	3%	0.05	2.7
EU 28	7 097	34%	0.7%	3%	0.05	2.7

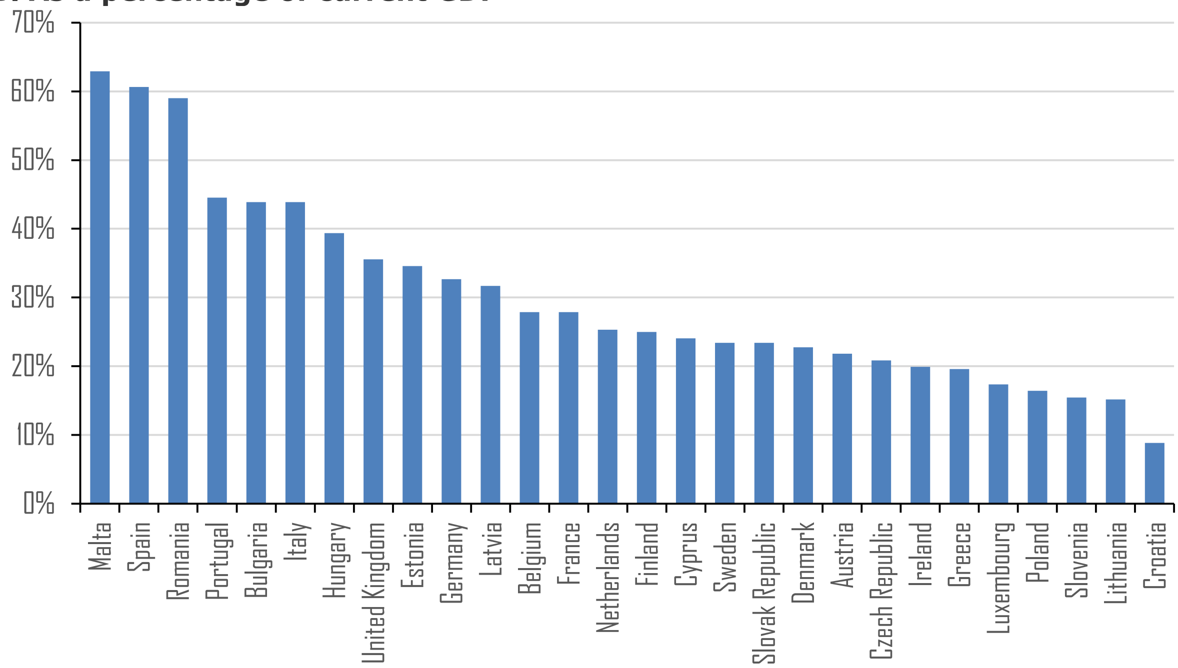
Notes: Discounted value of future increases in GDP until 2100 due to the reform, expressed in billion Euro (PPP), as a percentage of current GDP, and as a percentage of discounted future GDP. "GDP increase in year 2100" indicates by how much GDP in 2100 is higher due to the reform (in %). "Long-run growth increase" refers to increase in annual growth rate (in percentage points) once the whole labour force has reached higher level of educational achievement. "Increase in PISA score" refers to the ultimate increase in educational achievement due to the reform. See text for reform parameters.

Figure 4: Effect on GDP of Scenario 3: Enhancing skills of early school leavers

A. In billion Euro (PPP)



B. As a percentage of current GDP



Notes: Discounted value of future increases in GDP until 2100 due to the reform, expressed in billion Euro (PPP) and as a percentage of current GDP. See Table 4 for details.

Scenario 4: The Economic Benefits of Increasing Top Performance

Previous analysis has shown that economic growth is improved both by ensuring that all students have basic skills and by increasing the top portion of the achievement distribution. Gains from improving top performers reflect the importance of scientific and intellectual leadership in each country.

To capture the role of increased leadership, we project the economic impact of ensuring that each country has at least 15 percent of its students reaching level 5 or above in math and science by 2035.[13] In 2015, 9.2 percent of the EU student population reached this advanced level (on average across math and science), ranging from 2.0 percent in Romania to 13.9 percent in Estonia. For simulation purposes, we again assume that any programme to expand top performers has broader impacts past the group starting lower and lifted up to level 5 and that the spillovers are proportional to the size of the programme needed to achieve the basic level 5 goal. We assume that half of those already at level 5, as well as a group below the treated group and equal to half the size of the treated group, will get an improvement with half the score impact.

Table 5 shows the economic impact of policies aimed at boosting the top achieving group. Note that these policies again have limited impact on the highest performing EU countries, since they are already at or close to having 15 percent at level 5. The aggregate impact is € 4.6 trillion, 22 percent of current EU GDP.
Across countries, the absolute value of the reform is highest in Italy, Romania, and Spain at more than € 600 million each (see Figure 5, panel A). Relative to the current size the economy, Romania, Cyprus, Greece, and Bulgaria would gain the most (see Figure 5, panel B). These are the countries where currently less than 4 percent of students reach level 5. The relative effect is lowest in Estonia, Finland, and the Netherlands, where already more than 13 percent reach level 5 (on average across math and science).

When considering programmes for the top of the distribution, it is important to note that the current performance of the top EU countries does not equal the top from other parts of the world. Currently, Singapore and Taiwan have greater than 20 percent at level 5 or above, and Japan, Hong Kong, Korea, and Macao have greater than 15 percent, implying that there is room for feasible improvement even in the top EU countries.

[13] The boundary for level 5 is set at 607 in math and 633 in science (OECD (2016)). See Appendix D for a description of the skills involved in level 5 for math.

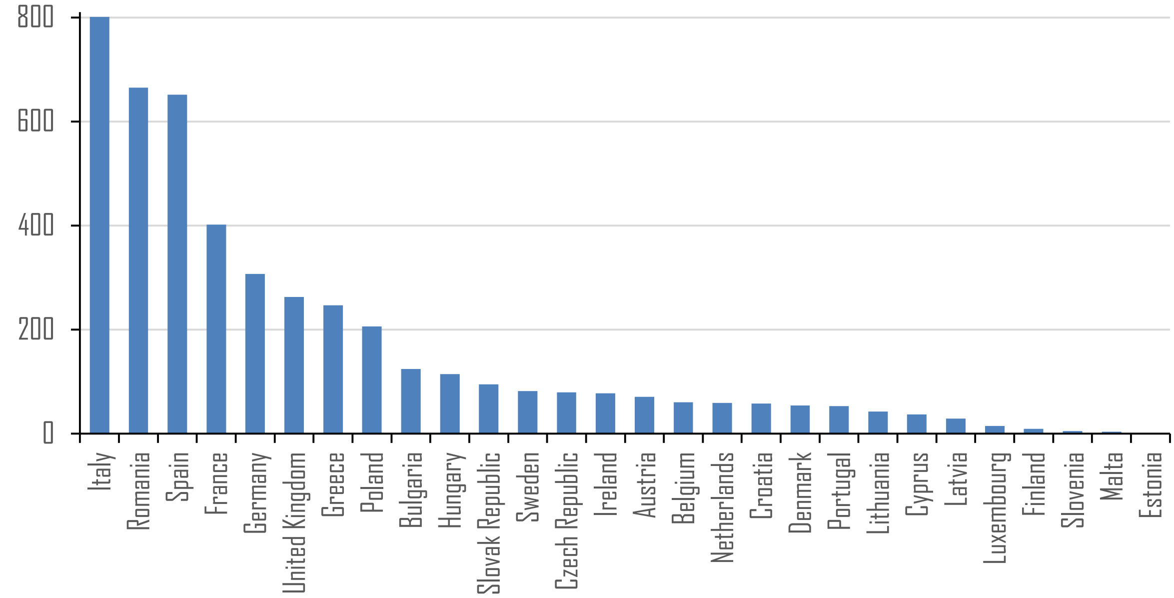
Table 4: Effect on GDP of Scenario 4: Increasing top performance

	Value of reform (bn €)	In % of current GDP	In % of discounted future GDP	GDP increase in year 2100	Long-run growth increase	Increase in PISA score
Austria	71	16%	0.3%	1%	0.03	1.3
Belgium	61	12%	0.3%	1%	0.02	0.9
Bulgaria	124	79%	1.7%	7%	0.12	6.2
Croatia	58	56%	1.2%	5%	0.09	4.4
Cyprus	37	111%	2.4%	9%	0.17	8.6
Czechia	80	21%	0.4%	2%	0.03	1.6
Denmark	54	19%	0.4%	2%	0.03	1.5
Estonia	1	1%	0.0%	0%	0.00	0.1
Finland	9	4%	0.1%	0%	0.01	0.3
France	402	14%	0.3%	1%	0.02	1.1
Germany	307	7%	0.2%	1%	0.01	0.6
Greece	247	83%	1.8%	7%	0.13	6.4
Hungary	115	38%	0.8%	3%	0.06	3.0
Ireland	78	21%	0.4%	2%	0.03	1.6
Italy	801	36%	0.8%	3%	0.06	2.8
Latvia	29	52%	1.1%	4%	0.08	4.1
Lithuania	43	46%	1.0%	4%	0.07	3.6
Luxembourg	15	23%	0.5%	2%	0.04	1.9
Malta	4	20%	0.4%	2%	0.03	1.6
Netherlands	59	6%	0.1%	1%	0.01	0.5
Poland	206	18%	0.4%	1%	0.03	1.4
Portugal	53	17%	0.4%	1%	0.03	1.4
Romania	665	133%	2.8%	11%	0.20	10.2
Slovakia	95	50%	1.1%	4%	0.08	3.9
Slovenia	5	7%	0.2%	1%	0.01	0.6
Spain	652	37%	0.8%	3%	0.06	2.9
Sweden	82	16%	0.3%	1%	0.02	1.3
United Kingdom	263	9%	0.2%	1%	0.01	0.7
EU 27 (w/o UK)	4 352	24%	0.5%	2%	0.04	1.9
EU 28	4 615	22%	0.5%	2%	0.04	1.9

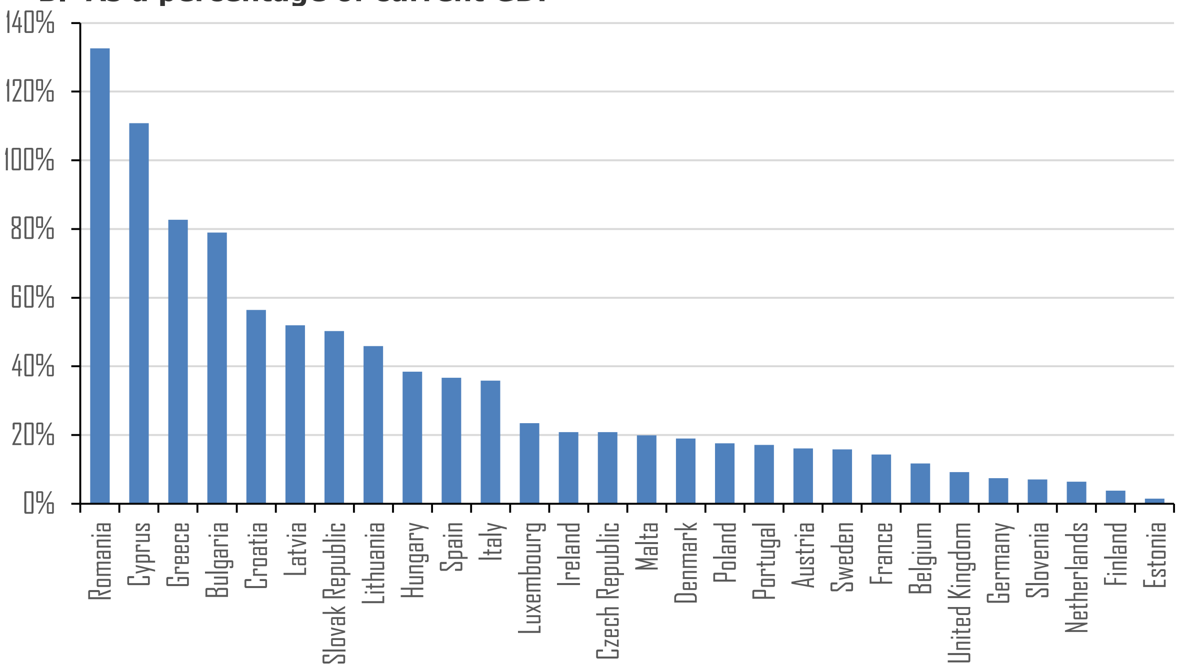
Notes: Discounted value of future increases in GDP until 2100 due to the reform, expressed in billion Euro (PPP), as a percentage of current GDP, and as a percentage of discounted future GDP. "GDP increase in year 2100" indicates by how much GDP in 2100 is higher due to the reform (in %). "Long-run growth increase" refers to increase in annual growth rate (in percentage points) once the whole labour force has reached higher level of educational achievement. "Increase in PISA score" refers to the ultimate increase in educational achievement due to the reform. See text for reform parameters.

Figure 5: Effect on GDP of Scenario 4: Increasing top performance

A. In billion Euro (PPP)



B. As a percentage of current GDP



Notes: Discounted value of future increases in GDP until 2100 due to the reform, expressed in billion Euro (PPP) and as a percentage of current GDP. See Table 5 for details.

Conclusions

The overarching conclusion of our analysis is that improvement of schools that boosts student achievement can have enormous impacts on the future economic wellbeing of EU countries. While the results of improvement take time before they are fully realised, the present value of gains shows that educational improvement could dramatically change the path of European economic development.

Europe has rightfully highlighted the importance of improving education across the EU. As the European Commission has emphasised, "A crucial part of the Europe 2020 agenda for smart, sustainable and inclusive growth is bolstering education and training."[14] With this in mind, the European Commission has set a variety of goals – goals that can be analysed directly. This study has taken scientific evidence about the relationship between achievement and economic growth to provide quantitative estimates of economic impacts from various feasible educational improvements.

Scenarios

We consider a series of alternative scenarios reflecting the European goals. They clearly show how systematic improvement of schools over the next 15 years would, according to historical growth relationships, yield significant economic benefits that would dramatically change the economic picture of Europe.

The easiest way to see this is the economic impact of **raising student achievement by 25 PISA points** (one-quarter standard deviation) across the EU. Portugal, Poland, and Germany demonstrated over the first fifteen years of the century that such gains are feasible. The present value of added GDP that resulted from increased long-run economic growth would be almost 3½ times current aggregate GDP in the EU. This would be equivalent to having average annual GDP seven percent higher throughout the remainder of the century.

Alternatively, for policies directed at low achievers, consider the economic gains from **bringing all students up at least to level 2** on the PISA tests. Of course, it is difficult and unrealistic to think of policies that targeted only students below level 2 and that did not spill over to those above this threshold goal. Thus, we consider achievement spillover gains that had in magnitude half the impact found for the low achievers and that reached a group half the size of the low achieving population in each country. These compensatory policies would yield aggregate gains of almost twice the current GDP in the EU.

This projection does go beyond the modest current EU goals that call for **reducing the low-achieving EU population to less than 15 percent** instead of zero. This policy obviously has less economic value, although it may be more realistic by acknowledging that some students – such as special education students – may not be feasibly brought up to level 2. (Note that three countries currently have already met the aggregate goal by having less than 15 percent of their students below level 2). As with the previous calculations, we still presume that the policies to meet this goal would have spillover effects to the bottom 15 percent equalling half the impact that the policies had on the target group. Such a policy would yield long-run economic gains of € 5 trillion.

A third policy objective arising from ET 2020 goals is to **reduce school leavers to 10 percent or less** in all countries. This policy has noticeably less impact on overall

[14] https://ec.europa.eu/education/policy/strategic-framework/et-monitor_en [accessed 9/6/2019].

economic results because it has no impact on the majority of students in EU countries. Indeed only 11 EU countries currently have greater than 10 percent school leavers. If **all school leavers had more schooling** (averaging approximately one year more), the present value of gains would be 34 percent of current aggregate GDP in the EU. If the improvement held just for the excess of leavers above 10 percent in each country, the gains would be sharply less – 6 percent of current GDP. Of course, while the aggregate impact is not large, the impact on individual students specifically affected could be significant.

An alternative scenario is to focus reform on the **top end of the achievement distribution**. We consider the economic impact of ensuring that each country has at least 15 percent of students above level 5 in math and science. This policy reflects the importance of higher achievers for providing scientific and intellectual leadership. Even though such a policy would only affect a limited share of the EU population, it would yield present value gains of € 4.6 trillion. Importantly, such a programme does not have to be an alternative to compensatory policies. It could be undertaken in parallel with policies aimed at lower portions of the distribution. An expanded version could also be undertaken by high achieving countries that wanted to expand their scientific base.
These projections are done one country at a time. Of course, with the significant mobility of individuals across EU labour markets, these policies can have immediate spillovers to other countries.

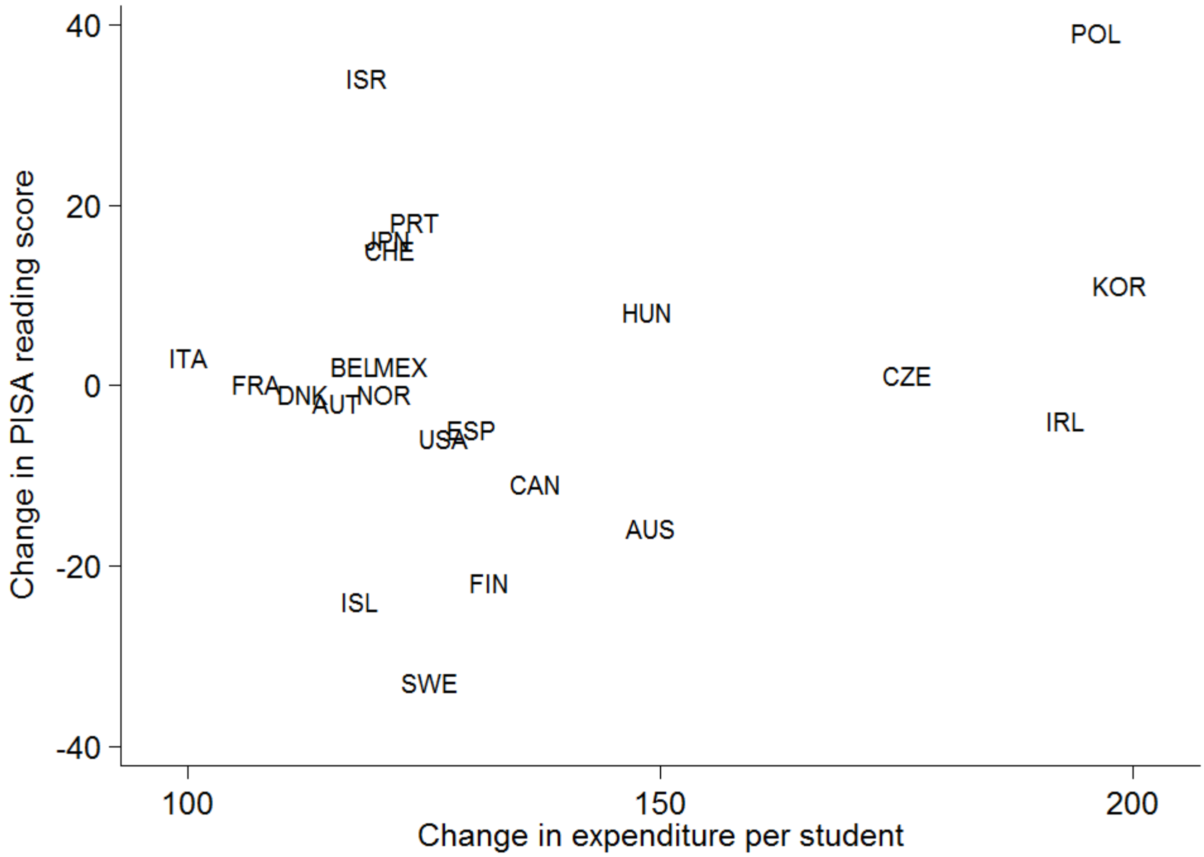
Policy Conclusions

Addressing exactly how any country should go about improving their schools goes beyond what we can do within this report. These questions have been extensively investigated elsewhere – and are the subject of continuing study.[15] There are, however, a few top-level conclusions that we draw from the existing analyses.

First, while the discussion of education policy is invariably couched in terms of “investing in education,” successful improvement requires much more than just putting added resources into the schools. While this issue has received an enormous amount of research attention, the substance is easiest to see by simply plotting increases in spending on schools against changes in student achievement across countries. As seen in Figure 6, there is **essentially no relationship between resource investments and changes in student achievement**. This figure does not say that money never has an impact on student achievement. Nor does it say that money cannot have an impact. It does say that money alone does not lead consistently to higher performance. It matters how any resources are used.

[15] See, e.g., Hanushek (2002), Hanushek and Woessmann (2011a, 2015a), and Woessmann (2003, 2016).

Figure 6: Changes in educational spending and in student achievement across countries



Notes: Scatter plot of the change in expenditure per student, 2000-2010 (constant prices, 2000 = 100) against change in PISA reading score, 2000-2012. Source: Hanushek and Woessmann (2015a).

Second, while there have been extensive discussions of proposals to adopt the programmes and policies of some subset of countries that are doing well on international tests, there is limited evidence that this approach will be successful. It is extraordinarily **difficult to pinpoint exactly why individual countries do as well as they do**, because there are many country policies simultaneously at play; because the separate country policies are imbedded in a variety of historical, societal, and cultural differences; and because both the demands and capacities of educational systems differ across countries.

Third, while more limited in application, the **use of incentives linked to student outcomes appears to be a more universally successful approach**. By rewarding people and programmes that demonstrate successful improvements in learning, resources can be channelled to places where they a demonstrably productive. This concept seems particularly appropriate for the interactions between finance ministries – which control much of educational funding – and education ministries – which control much of what happens in schools.

Education reform is challenging, because it takes time to see results and because it almost certainly requires changes from current policies and programmes. Given the time necessary to change policies and programmes and the time that passes before results are clearly seen, it is often compelling to delay actions – recognising that outcome changes may considerably lag the actual costs of change. The analysis of this report underscores the **societal costs of delay**.

The most fundamental conclusion must be a **recognition of the value of improved educational performance**. It is essential that countries realise that their **future is highly dependent on the quality of their schools**.

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Appendix A. Empirical Growth Model and Causation

The underlying statistical model that is the basis of the economic projections is fully described in Hanushek and Woessmann (2015a).[16] Here we summarise the technical details along with a description of analyses related to causation of cognitive skills.

Baseline Estimates

We think of a country's growth rate as a function of the skills of workers and other factors that include initial levels of income and technology, economic institutions, and other systematic factors. Skills are frequently referred to simply as the workers' human capital stock.

$$growth = \alpha_1 human\ capital + \alpha_2 other\ factors + \varepsilon \qquad (1)$$

This formulation suggests that nations with more human capital tend to make greater productivity gains than nations with less human capital.

The analyses focusing on cross-country differences in economic growth have frequently employed measures related to school attainment, or years of schooling, to test the human capital aspects of growth models. They have tended to find a significant positive association between quantitative measures of schooling and economic growth.[17]

Nevertheless, we believe that these formulations introduce substantial bias. Average years of schooling is a particularly incomplete and potentially misleading measure of education for comparing the human capital of different countries. It implicitly assumes that a year of schooling delivers the same increase in knowledge and skills regardless of the education system. Formulations relying on this measure also neglect any cross-country differences in the quality of schools and in the strength of family, health, and other influences.

A standard version of an education production function employed in a very extensive literature[18] would depict human capital as a function of a range of factors:

$$human\ capital = \beta_1 schools + \beta_2 families + \beta_3 ability + \beta_4 health + \beta_5 other\ factors + \mu \qquad (2)$$

In general, human capital combines both school attainment and its quality with the other relevant factors including education in the family, labour market experience, health, and so forth.

Thus, while school attainment has been convenient in empirical work because of its ready availability across countries, its use ignores differences in school quality in addition to other important determinants of people's skills. Incorporating variations in cognitive skills, which can be obtained through international assessments of mathematics, science, and reading achievement, can provide a direct measure of a country's human capital input.

The focus on cognitive skills has a number of potential advantages. First, it captures variations in the knowledge and ability that schools strive to produce and thus relates the putative outputs of schooling to subsequent economic success. Second, by emphasising total outcomes of education, it incorporates skills from any source – including schools, families, and ability. Third, by allowing for differences in performance among students with differing quality of schooling (but possibly the same quantity of schooling), it opens the investigation of the importance of different policies designed to affect the quality aspects

[16] This discussion relies heavily on the overview provided in Hanushek and Woessmann (2015b).

[17] To give an idea of the robustness of this association, an extensive empirical analysis by Sala-i-Martin, Doppelhofer, and Miller (2004) of 67 explanatory variables in growth regressions on a sample of 88 countries found that primary schooling was the most robust influence factor (after an East Asian dummy) on growth in GDP per capita in 1960-1996.

[18] See Hanushek (1986, 2002) for reviews.

of schools. Fourth, it is practical because of the extensive development of consistent and reliable cross-country assessments.

Our growth analysis relies on the measures of cognitive skills developed in Hanushek and Woessmann (2015a). Between 1964 and 2003, twelve different international tests of math, science, or reading were administered to a voluntarily participating group of countries.[19] These include 36 different possible scores for year-age-test combinations (e.g., science for students of grade 8 in 1972 as part of the First International Science Study or math of 15-year-olds in 2000 as a part of the first PISA test). The assessments are designed to identify a common set of expected skills, which were then tested in the local language. Each test is newly constructed, until recently with no effort to link to any of the other tests. Hanushek and Woessmann (2015a) describe the construction of consistent measures at the national level across countries through empirical calibration of the different tests.[20] These measures of knowledge capital for nations rely on the average (standardised) test scores for each country's historical participation in the tests. The aggregate scores are scaled (like PISA today) to have a mean of 500 and a standard deviation at the individual level of 100 across OECD countries.

We interpret the test scores as an index of the human capital of the populations (and workforce) of each country. This interpretation of our averages over different cohorts is reasonable if a country's scores have been stable across time, implying that estimates from recent school-aged populations provide an estimate of the older working population. If scores (and skills) do in fact change over time, some measurement error is clearly introduced. We know that scores have changed some, but within our period of observations differences in levels across countries dominate any intertemporal score changes.[21]

Using the aggregate test scores for each country – which we label its knowledge capital – we directly estimate how growth relates to this more refined measure of human capital.[22] Table A1 presents the basic results on the association between educational outcomes and long-run economic growth in the sample of 50 countries for which we have both economic growth data and our measure of knowledge capital.[23] The inclusion of initial GDP per capita in all specifications simply reflects the fact that it is easier to grow when one is farther from the technology frontier, because one just must imitate others rather than invent new things.

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[19] See Hanushek and Woessmann (2011a) for a review. Note that there have been seven major international assessments since 2003. We emphasise the early assessments because they fit into our analysis of long-run growth.

[20] By transforming the means and variances of the original country scores (partly based on external longitudinal test score information available for the United States), each is placed into a common distribution of outcomes. Each age group and subject is normalised to the PISA standard of mean 500 and individual standard deviation of 100 across OECD countries, and then all available test scores are averaged at the country level.

[21] For the 50 countries in our growth analysis, 73 percent of the variance in scores lies between countries (Hanushek and Woessmann (2012a)). The remaining 27 percent includes both true score changes and any measurement error in the tests. Any measurement error in this case will tend to bias downward the estimates of the impact of cognitive skills on growth, so that our estimates of economic implications will be conservative.

[22] The data on GDP per capita and its growth for our analyses come from the Penn World Tables (Heston, Summers, and Aten (2002)). Data on quantitative educational attainment are an extended version of the Cohen and Soto (2007) data. Results are very similar when using the latest Barro and Lee (2013) data on educational attainment; see Hanushek and Woessmann (2015a), Appendix 3A.

[23] See Hanushek and Woessmann (2012a, 2015a) for a more complete description of both the data and the estimation.

Table A1: Basic growth regressions:
Long-run growth in per-capita GDP, 1960-2000

	(1)	(2)	(3)
Cognitive skills		2.015***	1.980***
		(10.68)	*(9.12)*
Initial years of schooling (1960)	0.369***		0.026
	(3.23)		*(0.34)*
Initial GDP per capita (1960)	-0.379***	-0.287***	-0.302***
	(4.24)	*(9.15)*	*(5.54)*
Constant	2.785***	-4.827***	-4.737***
	(7.41)	*(6.00)*	*(5.54)*
Number of countries	50	50	50
R^2 (adj.)	0.252	0.733	0.728

Notes: Dependent variable: average annual growth rate in per-capita GDP, 1960 to 2000. Cognitive skill measure refers to average score on all international tests 1964 to 2003 in mathematics and science, primary through end of secondary school. *t*-statistics in parentheses: statistical significance at *** 1 percent. Source: Hanushek and Woessmann (2015).

When knowledge capital is ignored (column 1), years of schooling in 1960 are significantly associated with average annual growth rates in real GDP per capita in 1960-2000.[24] However, once our test measure of human capital is included (columns 2 and 3), we see that cognitive skills are highly significant while years of schooling become statistically insignificant and the estimated coefficient drops to close to zero. Furthermore, the variation in cross-country growth explained by the model increases from 25 percent to 73 percent when measuring human capital by cognitive skills rather than years of schooling.

The estimated coefficient on cognitive skills implies that an increase of one standard deviation in educational achievement (i.e., 100 test-score points on the PISA scale) yields an average annual growth rate over 40 years of observation that is two percentage points higher (i.e., 1.98 in column 3, Table A1). Figure 1 in the text depicts the fundamental association graphically, plotting growth in real per-capita GDP between 1960 and 2000 against average test scores after allowing for differences in initial GDP per capita and initial average years of schooling.

Causality in Brief

The fundamental question is: should we interpret this tight relationship between cognitive skills and economic growth as a causal one that can support direct policy actions?[25] In other words, if achievement were raised, would we really expect growth rates to go up by a commensurate amount? If the relationship between test scores and growth rates simply reflects other factors that are correlated with both test scores and growth rates, a change in test scores may have little or no impact on the economy.

Work on differences in growth among countries, while extensive over the past two decades, has been plagued by legitimate questions about whether any truly causal effects have been identified, or whether the estimated statistical analyses simply pick up a

[24] To avoid the 2008 global recession, its aftermath, and any potential bubbles building up beforehand, the growth analysis stops in 2000, but results are very similar when extending the growth period to 2007 or 2009; see Hanushek and Woessmann (2015a), Appendix 3A.

[25] This section summarises the detailed analysis found in Hanushek and Woessmann (2015a).

correlation that emerges for other reasons. Studies finding positive effects of years of schooling on economic growth may indeed suffer from reverse causality, that is, improved growth was leading to more schooling rather than the reverse (e.g., Bils and Klenow (2000)). If a country gets richer, it tends to buy more of many things, including more years of schooling for its population.

There is less reason to think that higher student achievement is caused by economic growth. For one thing, scholars have found little impact of additional education spending on achievement outcomes (reviewed in Hanushek and Woessmann (2011a)), so it is unlikely that the relationship comes from growth-induced resources lifting student achievement.

Here we consider major factors that could confound the growth results reported above. We summarise here our investigations into the potential problems with the prior estimation and their likely severity. These have been more fully reported in Hanushek and Woessmann (2015a).

First, the estimated relationship is little affected by including other possible determinants of economic growth. In an extensive investigation of alternative model specifications, we employ different measures of cognitive skills, various groupings of countries (including some that eliminate regional differences), and specific sub-periods of economic growth. These efforts show a consistency in the alternative estimates, in both quantitative impacts and statistical significance. Moreover, measures of geographical location, political stability, capital stock, and population growth do not significantly affect the estimated impact of cognitive skills. These specification tests rule out many basic problems attributable to omitted causal factors that have been noted in prior growth work.

Second, our analysis relates growth rates over the period 1960 to 2000 to test scores for roughly the same period. To address possible reverse causality directly, we separate the timing of the analysis by estimating the effect of scores on tests conducted only until 1984 on economic growth in the period from 1985 to 2009. In this analysis, available for a sample of 25 countries only, test scores strictly pre-date the growth period, making it clear that increased growth could not be causing the higher test scores of the prior period. This estimation shows a positive effect of early test scores on subsequent growth rates that is almost twice as large as that displayed in Table A1.

Third, we cannot be sure that the important international differences in test scores reflect school policies. Achievement could just reflect health and nutrition differences in the population or cultural differences regarding learning and testing. If we focus attention just on variations in achievement that arise directly from institutional characteristics of each country’s school system (exit examinations, autonomy, relative teacher salaries, and private schooling),[26] the estimated growth relationship yields essentially the same results as previously presented.

Fourth, a major concern is that countries with good economies also have good school systems, implying that those that grow faster because of the basic economic factors also have high achievement. In this case, achievement may not be the driving force in growth. One simple approach is to consider the implications of differences in measured skills within a single economy, thus eliminating institutional or cultural factors that may make the economies of different countries grow faster. This can readily be done for

[26] The formal approach is called “instrumental variables.” In order for this to be a valid approach, it must be the case that the institutions are not themselves related to differences in growth beyond their relation with test scores. For a fuller discussion, see Hanushek and Woessmann (2012a).

immigrants to the U.S. who have been educated in their home countries and who can be compared to those immigrants educated just in the U.S. Looking at labour-market returns, the cognitive skills seen in the immigrant's home country lead to higher incomes, but only if the immigrant was in fact educated in the home country. This comparative analysis rules out the possibility that test scores simply reflect cultural factors or economic institutions of the home country. It also lends further support to the potential role of schools in changing the cognitive skills of citizens in economically meaningful ways.

Finally, for those countries that have participated in testing at different points over the past half century, we can observe whether or not students seem to be getting better or worse over time. If test-score improvements actually increase growth rates, gains in test scores should be related to improvements in annual growth rates of countries. This approach implicitly eliminates country-specific economic and cultural factors because it looks at what happens over time within each country. For 12 OECD countries that permit tracking this relationship, the gains in test scores over time are very closely related to the gains in growth rates over time.

Each approach to determining causation is subject to its own uncertainty. Nonetheless, the combined evidence consistently points to the conclusion that differences in cognitive skills lead to significant differences in economic growth.
Since the causality tests concentrate on the impact of schools, the evidence suggests that school policy can, if effective in raising cognitive skills, be an important force in economic development. While other factors – culture, health, and so forth – may also affect the level of cognitive skills in an economy, schools clearly contribute to the development of human capital. More years of schooling in a system that is not well designed to enhance learning, however, will have little effect.

Appendix B. The Simulation Model

The estimate of the empirical growth model discussed in Appendix A suggests that each standard deviation in educational achievement relates to 1.98 percent higher annual growth in GDP. This estimate allows us to simulate how future growth rates of the economy would develop after an increase in educational achievement. The basic setup of the simulation model follows the OECD study by Hanushek and Woessmann (2015b).[27]

For each of the 28 EU Member States, we measure student achievement on the most recent PISA test of 2015 (OECD (2016)), depicted in Table C1 in Appendix C. We use the underlying PISA micro database to model the different reform scenarios that depict how students improve due to alternative policy reforms. As the underlying growth research uses average math and science skills, the projections are also based on average achievement in these two subjects.

The base year of the projections is 2020. Estimates of countries' GDP in 2020 are provided by the International Monetary Fund (2019). The GDP figures are based on purchasing power parity (PPP) calculations in current international dollars and are converted into euros using the reference exchange rate over the past half year provided by the European Central Bank (1 EUR = 1.1391 USD). The time horizon of the projections is taken as the life expectancy of a child born today, i.e., an 80-year period. Accordingly, the projections span from 2020 to 2100. We also report results of shorter projections over a 40-year period.

We project how the GDP of each EU country would develop without and with improved educational achievement. In the status quo situation (without policy change), the future growth rate of the economies at current skill levels is projected to be 1.5 percent, which is roughly the average growth of GDP per capita for OECD countries over the past two decades. Future GDP values and future gains in GDP are discounted to the present with a 3 percent discount rate. All projected values of future GDP and GDP gains are reported in present value terms and are thus directly comparable to the current levels of GDP.[28]

The projections of future GDP trajectories with improved educational achievement after educational reforms rely on a simple description of how skills enter the labour market and have an impact on the economy. As educational reforms cannot improve schools overnight, the analysis assumes that improvements occur linearly from today's schooling situation to attainment of the respective policy scenario in 15 years. But of course, the labour force itself will only become more skilled as increasing numbers of new, better-trained people enter the labour market and replace the less-skilled individuals who retire. The analysis assumes that a worker remains in the labour force for 40 years, implying that the labour force will not be made up of fully skilled workers until 55 years have passed (15 years of reform and 40 years of replacing less-skilled workers as they retire).

[27] Earlier studies using a similar model framework include Hanushek and Woessmann (2010b, 2011b, 2015a), which provide additional details on the projection methodology (applied to somewhat different policy scenarios). Hanushek and Woessmann (2010a, 2012b) provided prior estimates for the European Union using PISA data from 2006 and GDP data for 2010. Hanushek, Ruhose, and Woessmann (2017a, 2017b) provide similar growth analyses and projections for US states.

[28] Present value calculations weight resources in the distant future less than current resources, reflecting both the uncertainty about future events and the desire to have economic impacts more quickly. The calculations here, based on a 3 percent discount rate, provide a direct indication of the size of current aggregate impacts (for improved GDP) that – if invested at 3 percent – could produce all of the future results from projected added growth.

The growth rate of the economy is calculated each year into the future based on the average skills of workers (which changes as new, more skilled workers enter), multiplied by the historic estimate of how skills affect annual growth. The difference between the projected future GDPs with status-quo skills and those with the improved workforce, i.e., the gain in GDP due to the reform, then provides an estimate of the economic value of the reform, or the economic benefit of improved educational achievement.

Appendix C. Additional Tables

Table C1: Country performance, early school leaving, and GDP

	Average score	Math score	Science score	Increased score	Share below level 2	Share reaching level 5	Early school leavers	GDP
Austria	495.9	496.7	495.0	510.1	0.214	0.101	6.9	440
Belgium	504.5	507.0	502.0	518.1	0.200	0.124	8.8	518
Bulgaria	443.5	441.2	445.8	478.4	0.400	0.037	13.8	158
Croatia	469.7	464.0	475.4	488.1	0.284	0.048	2.8	103
Cyprus	434.9	437.1	432.6	470.2	0.424	0.024	7.6	33
Czechia	492.6	492.3	492.8	506.0	0.212	0.089	6.6	383
Denmark	506.5	511.1	501.9	514.7	0.148	0.094	7.2	285
Estonia	526.9	519.5	534.2	531.6	0.101	0.139	10.9	43
Finland	520.9	511.1	530.7	528.2	0.125	0.130	7.9	243
France	493.9	492.9	495.0	510.3	0.228	0.097	8.8	2 800
Germany	507.6	506.0	509.1	518.2	0.171	0.118	10.3	4 140
Greece	454.2	453.6	454.8	480.0	0.343	0.030	6.2	299
Hungary	476.8	476.8	476.7	496.3	0.270	0.064	12.4	298
Ireland	503.1	503.7	502.6	511.4	0.152	0.085	6.3	372
Italy	485.1	489.7	480.5	500.7	0.233	0.073	13.8	2 233
Latvia	486.3	482.3	490.2	496.7	0.194	0.045	10.0	56
Lithuania	476.9	478.4	475.4	492.9	0.251	0.056	4.8	94
Luxembourg	484.3	485.8	482.8	501.4	0.259	0.085	5.5	65
Malta	471.7	478.6	464.8	501.3	0.309	0.098	19.7	21
Netherlands	510.4	512.3	508.6	521.4	0.177	0.134	8.0	932
Poland	503.0	504.5	501.4	512.4	0.168	0.098	5.2	1 171
Portugal	496.4	491.6	501.1	509.6	0.206	0.094	14.0	310
Romania	439.4	444.0	434.9	467.2	0.393	0.020	18.5	502
Slovakia	468.0	475.2	460.8	491.4	0.293	0.057	7.4	189
Slovenia	511.4	509.9	512.9	520.3	0.156	0.121	4.9	74
Spain	489.3	485.8	492.8	501.9	0.203	0.061	19.0	1 777
Sweden	493.7	493.9	493.4	508.4	0.213	0.095	7.4	517
United Kingdom	500.9	492.5	509.2	513.7	0.197	0.108	11.2	2 856
EU 27 (w/o UK)	486.9	486.9	487.0	503.2	0.234	0.082		18 053
EU 28	487.4	487.1	487.8	503.6	0.233	0.083	10.7	20 909

Notes: Average/math/science score: average math/science score in PISA 2015. Increased score: average score after implementing scenario 2. Share below level 2: Share of students performing below PISA level 2 (average of math and science). Share reaching level 5: Share of students performing at or above PISA level 5 (average of math and science). Early school leavers: early leavers from education and training, 2016 (European Commission (2017a), Table 1). GDP: gross domestic product in 2020, in billion Euro (transformed from current international dollar, in purchasing-power-parity), IMF estimate (International Monetary Fund (2019)).

Table C2: Effect on GDP after 40 years

	Scenario 1	Scenario 2	Scenario 3	Scenario 4
Austria	237	107	16	12
Belgium	279	120	24	10
Bulgaria	85	95	12	21
Croatia	56	33	2	10
Cyprus	18	20	1	6
Czechia	206	88	13	13
Denmark	154	40	11	9
Estonia	23	3	2	0
Finland	131	30	10	2
France	1 511	783	131	67
Germany	2 234	752	226	52
Greece	161	132	10	41
Hungary	161	100	20	19
Ireland	201	53	12	13
Italy	1 205	594	163	134
Latvia	30	10	3	5
Lithuania	50	26	2	7
Luxembourg	35	19	2	3
Malta	11	11	2	1
Netherlands	503	174	40	10
Poland	632	188	32	35
Portugal	167	70	23	9
Romania	271	240	49	109
Slovakia	102	76	7	16
Slovenia	40	11	2	1
Spain	958	382	179	109
Sweden	279	130	20	14
United Kingdom	1 541	628	170	44
EU 27 (w/o UK)	9 740	4 286	1 016	726
EU 28	11 280	4 914	1 186	770

Notes: Discounted value of future increases in GDP until 2050 due to the reform, expressed in billion Euro (PPP). See text for reform parameters.

Table C3: Effect on GDP of at most 15 percent of students below level 2 in each country

	Value of reform (bn €)	In % of current GDP	In % of discounted future GDP	GDP increase in year 2100	Long-run growth increase	Increase in PISA score
Austria	101	23%	0.5%	1.9%	0.04	1.8
Belgium	93	18%	0.4%	1.5%	0.03	1.4
Bulgaria	304	193%	4.1%	16.5%	0.29	14.7
Croatia	64	62%	1.3%	5.2%	0.10	4.8
Cyprus	67	202%	4.3%	17.3%	0.30	15.3
Czechia	79	21%	0.4%	1.7%	0.03	1.6
Denmark	0	0%	0.0%	0.0%	0.00	0.0
Estonia	0	0%	0.0%	0.0%	0.00	0.0
Finland	0	0%	0.0%	0.0%	0.00	0.0
France	925	33%	0.7%	2.8%	0.05	2.6
Germany	231	6%	0.1%	0.5%	0.01	0.4
Greece	341	114%	2.4%	9.6%	0.17	8.8
Hungary	180	60%	1.3%	5.1%	0.09	4.7
Ireland	6	2%	0.04%	0.1%	0.00	0.1
Italy	717	32%	0.7%	2.7%	0.05	2.5
Latvia	7	13%	0.3%	1.1%	0.02	1.0
Lithuania	37	40%	0.9%	3.3%	0.06	3.1
Luxembourg	31	48%	1.0%	4.0%	0.07	3.8
Malta	23	112%	2.4%	9.4%	0.17	8.6
Netherlands	79	8%	0.2%	0.7%	0.01	0.7
Poland	49	4%	0.1%	0.3%	0.01	0.3
Portugal	74	24%	0.5%	2.0%	0.04	1.9
Romania	720	144%	3.1%	12.2%	0.22	11.0
Slovakia	149	79%	1.7%	6.6%	0.12	6.2
Slovenia	2	2%	0.04%	0.2%	0.00	0.2
Spain	323	18%	0.4%	1.5%	0.03	1.4
Sweden	118	23%	0.5%	1.9%	0.04	1.8
United Kingdom	503	18%	0.4%	1.5%	0.03	1.4
EU 27 (w/o UK)	4 720	26%	0.6%	2.2%	0.05	2.7
EU 28	5 223	25%	0.5%	2.1%	0.05	2.6

Notes: Discounted value of future increases in GDP until 2100 due to the reform, expressed in billion Euro (PPP), as a percentage of current GDP, and as a percentage of discounted future GDP. "GDP increase in year 2100" indicates by how much GDP in 2100 is higher due to the reform (in %). "Long-run growth increase" refers to increase in annual growth rate (in percentage points) once the whole labour force has reached higher level of educational achievement. "Increase in PISA score" refers to the ultimate increase in educational achievement due to the reform. See text for reform parameters.

Table C4: Effect on GDP of reducing early school leaving to 10 percent in each country

	Value of reform (bn €)	In % of current GDP	In % of discounted future GDP	GDP increase in year 2100	Long-run growth increase	Increase in PISA score
Austria	0	0%	0.0%	0%	0.00	0.0
Belgium	0	0%	0.0%	0%	0.00	0.0
Bulgaria	19	12%	0.3%	1%	0.02	1.0
Croatia	0	0%	0.0%	0%	0.00	0.0
Cyprus	0	0%	0.0%	0%	0.00	0.0
Czechia	0	0%	0.0%	0%	0.00	0.0
Denmark	0	0%	0.0%	0%	0.00	0.0
Estonia	1	3%	0.1%	0%	0.00	0.2
Finland	0	0%	0.0%	0%	0.00	0.0
France	0	0%	0.0%	0%	0.00	0.0
Germany	39	1%	0.0%	0%	0.00	0.1
Greece	0	0%	0.0%	0%	0.00	0.0
Hungary	23	8%	0.2%	1%	0.01	0.6
Ireland	0	0%	0.0%	0%	0.00	0.0
Italy	268	12%	0.3%	1%	0.02	1.0
Latvia	0	0%	0.0%	0%	0.00	0.0
Lithuania	0	0%	0.0%	0%	0.00	0.0
Luxembourg	0	0%	0.0%	0%	0.00	0.0
Malta	6	31%	0.7%	3%	0.05	2.4
Netherlands	0	0%	0.0%	0%	0.00	0.0
Poland	0	0%	0.0%	0%	0.00	0.0
Portugal	39	13%	0.3%	1%	0.02	1.0
Romania	135	27%	0.6%	2%	0.04	2.1
Slovakia	0	0%	0.0%	0%	0.00	0.0
Slovenia	0	0%	0.0%	0%	0.00	0.0
Spain	506	29%	0.6%	2%	0.04	2.3
Sweden	0	0%	0.0%	0%	0.00	0.0
United Kingdom	108	4%	0.1%	0%	0.01	0.3
EU 27 (w/o UK)	1 037	6%	0.1%	0%	0.00	0.0
EU 28	1 144	5%	0.1%	0%	0.00	0.2

Notes: Discounted value of future increases in GDP until 2100 due to the reform, expressed in billion Euro (PPP), as a percentage of current GDP, and as a percentage of discounted future GDP. "GDP increase in year 2100" indicates by how much GDP in 2100 is higher due to the reform (in %). "Long-run growth increase" refers to increase in annual growth rate (in percentage points) once the whole labour force has reached higher level of educational achievement. "Increase in PISA score" refers to the ultimate increase in educational achievement due to the reform. See text for reform parameters.

Appendix D. Description of the PISA Proficiency Levels in Mathematics

Level	What students can typically do
6	At Level 6, students can conceptualize, generalize and utilize information based on their investigations and modelling of complex problem situations, and can use their knowledge in relatively non-standard contexts. They can link different information sources and representations and flexibly translate among them. Students at this level are capable of advanced mathematical thinking and reasoning. These students can apply this insight and understanding, along with a mastery of symbolic and formal mathematical operations and relationships, to develop new approaches and strategies for attacking novel situations. Students at this level can reflect on their actions, and can formulate and precisely communicate their actions and reflections regarding their findings, interpretations, arguments, and the appropriateness of these to the original situation.
5	At Level 5, students can develop and work with models for complex situations, identifying constraints and specifying assumptions. They can select, compare and evaluate appropriate problem-solving strategies for dealing with complex problems related to these models. Students at this level can work strategically using broad, well-developed thinking and reasoning skills, appropriate linked representations, symbolic and formal characterizations, and insight pertaining to these situations. They begin to reflect on their work and can formulate and communicate their interpretations and reasoning.
4	At Level 4, students can work effectively with explicit models for complex, concrete situations that may involve constraints or call for making assumptions. They can select and integrate different representations, including symbolic, linking them directly to aspects of real-world situations. Students at this level can utilize their limited range of skills and can reason with some insight, in straightforward contexts. They can construct and communicate explanations and arguments based on their interpretations, arguments and actions.
3	At Level 3, students can execute clearly described procedures, including those that require sequential decisions. Their interpretations are sufficiently sound to be a base for building a simple model or for selecting and applying simple problem-solving strategies. Students at this level can interpret and use representations based on different information sources and reason directly from them. They typically show some ability to handle percentages, fractions and decimal numbers, and to work with proportional relationships. Their solutions reflect that they have engaged in basic interpretation and reasoning.
2	At Level 2, students can interpret and recognize situations in contexts that require no more than direct inference. They can extract relevant information from a single source and make use of a single representational mode. Students at this level can employ basic algorithms, formulae, procedures or conventions to solve problems involving whole numbers. They are capable of making literal interpretations of the results.
1	At Level 1, students can answer questions involving familiar contexts where all relevant information is present and the questions are clearly defined. They are able to identify information and to carry out routine procedures

according to direct instructions in explicit situations. They can perform actions that are almost always obvious and follow immediately from the given stimuli.

Source: OECD (2016).

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