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Seizing the productive potential of digital change in Estonia

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SEIZING THE PRODUCTIVE POTENTIAL OF DIGITAL CHANGE IN ESTONIA

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Abstract / Resumé

Seizing the productive potential of digital change in Estonia

Technologies such as cloud computing, software to automate supplier- and customer relations, online platforms and artificial intelligence seem to offer a vast potential to boost productivity and living standards. However, aggregate productivity growth has declined sharply across the OECD over the past decades. Estonia is no exception, though it is well placed to gain from digital technology diffusion, with strong digital foundations, including advanced and secure physical and digital infrastructure and world-leading e-government services. Turning this potential into a productivity boost necessitates speeding up digital take-up also outside of the ICT sector and fostering the complementarities between digital technologies, skills and policies. Skills are high in general, and the supply of ICT specialists is picking up. There is still potential to improve digital user skills, and notably to put skills to better use by improving management skills and practices. Business-friendly regulations in general and pioneering attempts in some areas will likely spur the adoption of digital technologies. However, insolvencies are too slow and costly, command-and-control regulations relatively frequent and public ownership in network industries is high. Strengthening collaboration between industry associations, labour unions and industry clusters within technology investments, internationalisation, skill supply and management practices could help the country better realise complementarities between technologies, skills and policies, and thereby tap deeper into the productivity potential offered by digital technologies.

This Working Paper relates to the 2019 OECD Economic Survey of Estonia
http://www.oecd.org/economy/estonia-economic-snapshot/
Keywords: Digitalisation, productivity, skills, automation.
JEL classification codes: D24, D47, E22, J24, O33, O38.

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Saisir le potentiel productif du changement numérique en Estonie

Les technologies telles que le cloud computing, les logiciels d'automatisation des relations avec les fournisseurs et les clients, les plateformes en ligne et l'intelligence artificielle semblent offrir un vaste potentiel pour améliorer la productivité et le niveau de vie. Cependant, la croissance de la productivité globale a fortement baissé dans l'ensemble de l'OCDE au cours des dernières décennies. L'Estonie ne fait pas exception, même si elle est bien placée pour tirer profit de la diffusion de la technologie numérique, avec des bases numériques solides, notamment des infrastructures physiques et numériques avancées et sécurisées et des services d'administration en ligne de premier plan. Transformer ce potentiel en une augmentation de la productivité nécessite d'accélérer l'adoption du numérique également en dehors du secteur des TIC et de favoriser les complémentarités entre les technologies numériques, les compétences et les politiques. Les compétences sont généralement élevées et l'offre de spécialistes des TIC augmente. Il existe encore un potentiel pour améliorer les compétences des utilisateurs numériques, et notamment pour mieux les utiliser en améliorant les compétences et les pratiques de gestion. Des réglementations favorables aux entreprises en général et des tentatives novatrices dans certains domaines stimuleront probablement l'adoption des technologies numériques. Cependant, les insolvabilités sont trop lentes et coûteuses, les réglementations de commandement et de contrôle relativement fréquentes et la propriété publique dans les industries de réseau est élevée. Le renforcement de la collaboration entre les associations industrielles, les syndicats et les grappes industrielles dans le cadre des investissements technologiques, de l'internationalisation, de l'offre de compétences et des pratiques de gestion pourrait aider le pays à mieux réaliser les complémentarités entre les technologies, les compétences et les politiques, et ainsi exploiter plus profondément le potentiel de productivité offert par les technologies numériques.

Ce document de travail est lié à l'Étude économique de l'OCDE de 2019 consacrée à l'Estonie.
http://www.oecd.org/fr/economie/estonie-en-un-coup-d-oeil/
Mots clés: numérisation, productivité, compétences, automatisation.
Codes JEL: D24, D47, E22, J24, O33, O38.

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Seizing the productive potential of digital change in Estonia

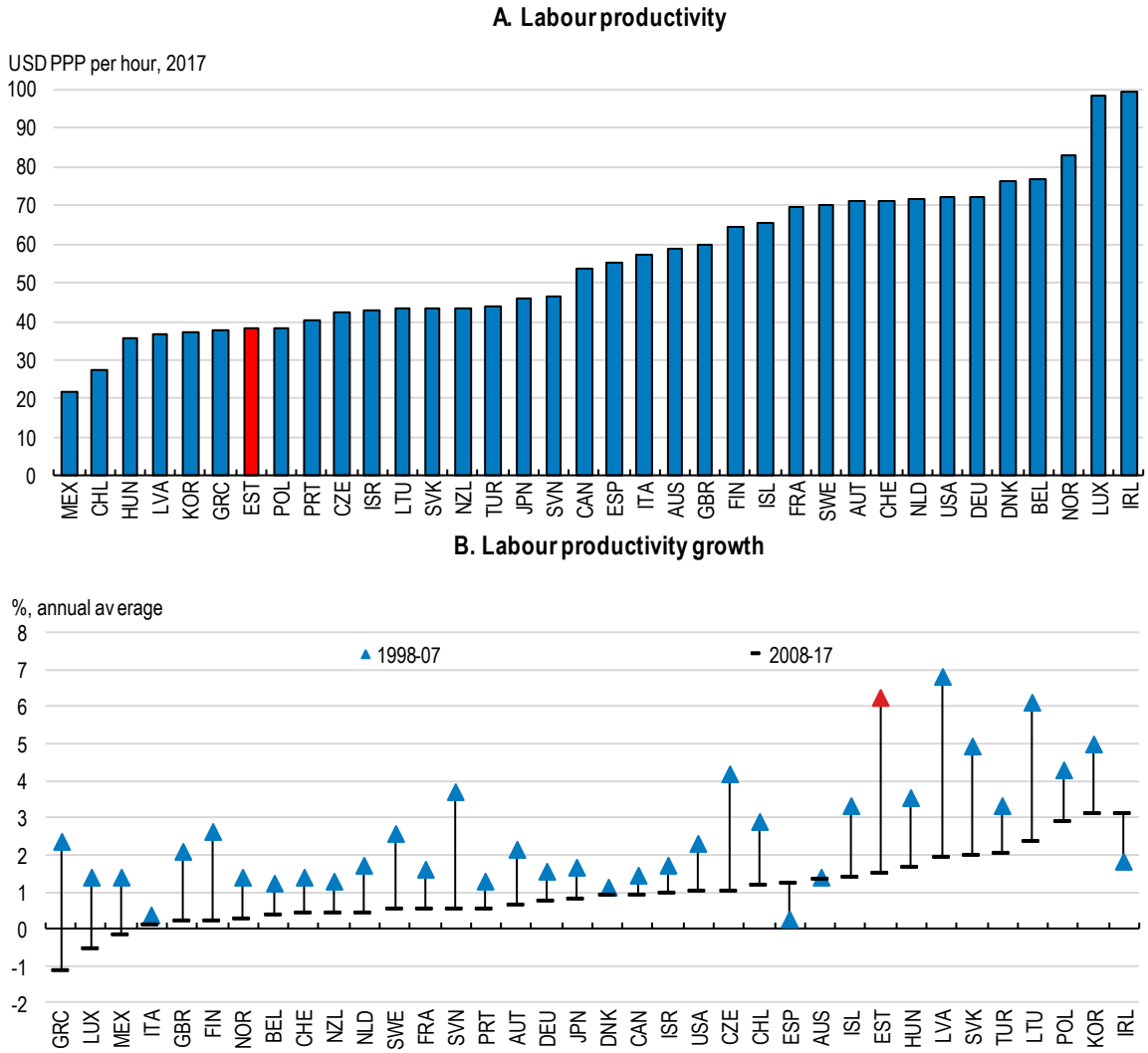
By: Damien Azzopardi, Patrick Lenain, Margit Molnar, Natia Mosiashvili and Jon Pareliussen[1]

Productivity needs a boost, and digital technologies can help

1. Digital technologies change the fabric of our economies. Governments have new ways to interact with and provide services to citizens and firms. Firms have new tools to design, produce and market goods and services, and to interact with other firms, workers, consumers and governments. Individuals have new tools for social and economic interactions. Technologies such as cloud computing, software to automate supplier- and customer relations, online platforms and artificial intelligence seem to offer a vast potential to boost productivity and living standards, but aggregate productivity growth has on the contrary declined sharply across the OECD the past decades. Estonia is no exception. Labour productivity growth was impressive from the 1990s, following independence from the Soviet Union, but has slowed since the Global Financial Crisis (Figure 1: OECD, 2019a).

[1] The authors, all working in the OECD Economics Department, would like to thank Christina Von Rueden, Dirk Pilat and Isabell Koske for valuable comments and suggestions at various stages of the preparation of this paper. The team are grateful to the Government of Estonia for good discussions and warm hospitality in two missions leading up to the 2019 OECD Economic Survey of Estonia. Special thanks go to Andrus Säälik, Martin Pöder and Kristiina Abel. Thanks to Stephanie Henry and Heloise Wickramanaya for secretarial assistance.

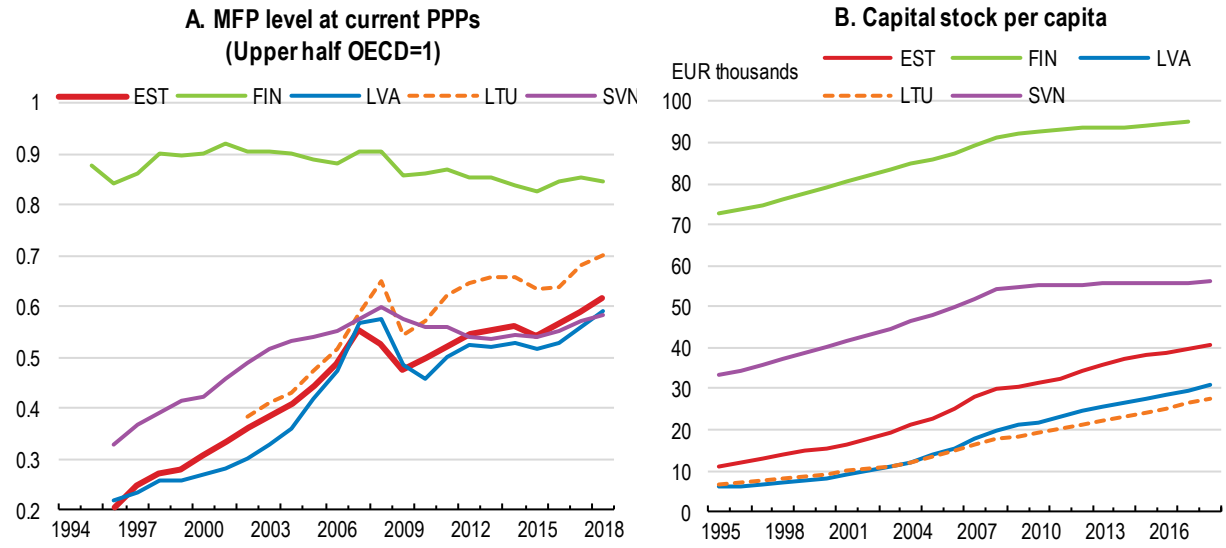
Figure 1. Productivity growth has declined sharply in many countries, including Estonia



Note: Labour productivity is measured as GDP per hour worked. For Ireland, the data on productivity growth (Panels B and C) exclude the foreign-owned multinational enterprise dominated sector and cover 2000-16 (source: Irish Central Statistics Office).
Source: OECD Economic Outlook 105.

2. Estonia has considerable potential to gain from adopting efficient technologies, as the multi-factor productivity (MFP) gap remains wide, not only compared to the United States and advanced EU economies, but also compared to many Central and Eastern European countries (Figure 2, Panel A). On the other hand, stable investment growth has steadily increased the per capita capital stock, even though the level of capital per capita is still to catch up with high-income OECD countries and some advanced Central and Eastern European economies, such as Slovenia (Panel B).

Figure 2. Weak multifactor productivity growth contrasts relatively strong capital accumulation

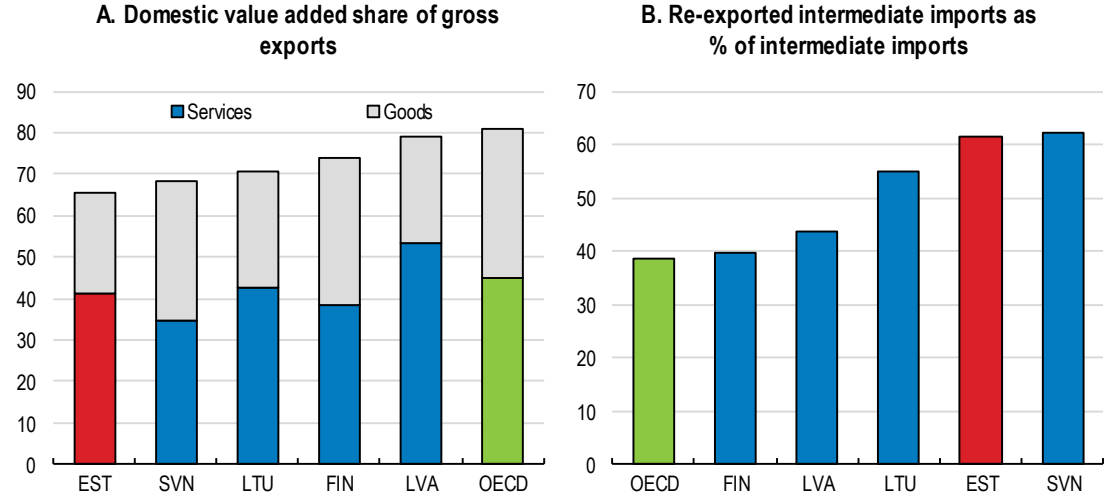


Source: OECD Economic Outlook 105 database.

3. Low productivity is related to Estonia's very low share of domestic value added in final demand at just over 58%, the fifth lowest in the OECD. Exports, similarly, have a high share of foreign value added, and a great deal of intermediate imports are re-exported (Figure 3), reflecting that Estonian production is often situated in low value-added mid-stream activities of global value chains (GVCs), such as manufacturing and assembly (Ali-Yrkkö et al., 2017).

4. Benkovskis et al. (2017) show that Estonian companies who export are more productive than those who do not. High-performing firms are more likely to start exporting, but non-exporting firms who start to export see a significant productivity boost on average, which is driven by those entering high-value-added upstream activities in GVCs. Nonetheless, widespread foreign ownership of companies may be an impediment to local product development and thus capturing more lucrative up-stream and down-stream activities such as research, design and marketing (Valdani Vicari and Associates and Wik Consult, 2018). Indeed, foreign firms appear attracted by natural endowments (wood, oil, etc.) and relatively cheap labour, and consider the country as a production base. However, with wages catching up, higher value-added activities need to be captured to ensure stable productivity gains in the longer run, and there are signs that this process has gathered pace lately (Eesti Pank, 2019).

Figure 3. Exporters are heavily relying on foreign inputs



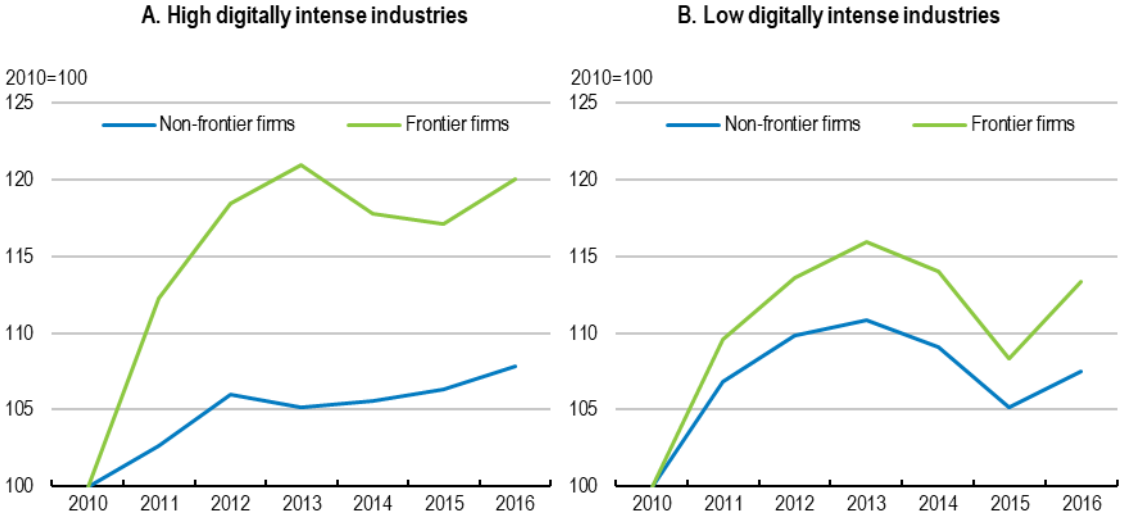
Source: OECD TiVA database.

5. The productivity slowdown across the OECD has multiple and partly interlinked reasons, some related to the legacy of the global financial crisis, for example that spare capacity is high and access to finance difficult in a protracted cyclical downturn have held back investments in tangible and intangible capital in some countries and industries. However, productivity growth started slowing down before the crisis in most OECD countries and remains weak to date, suggesting an important role for structural factors.

6. Previous OECD research indicates that productivity performance of the best performing firms ("the productivity frontier") has continued to grow at least as fast as before, while the divergence between the frontier and the rest has increased, holding back aggregate productivity (Andrews et al., 2016). This pattern also holds for Estonia, and divergence is particularly strong in digitally intensive industries (Figure 4).

Figure 4. Productivity dispersion has increased in Estonia, especially in digital intensive industries

Labour productivity at the frontier and for the average non-frontier firm



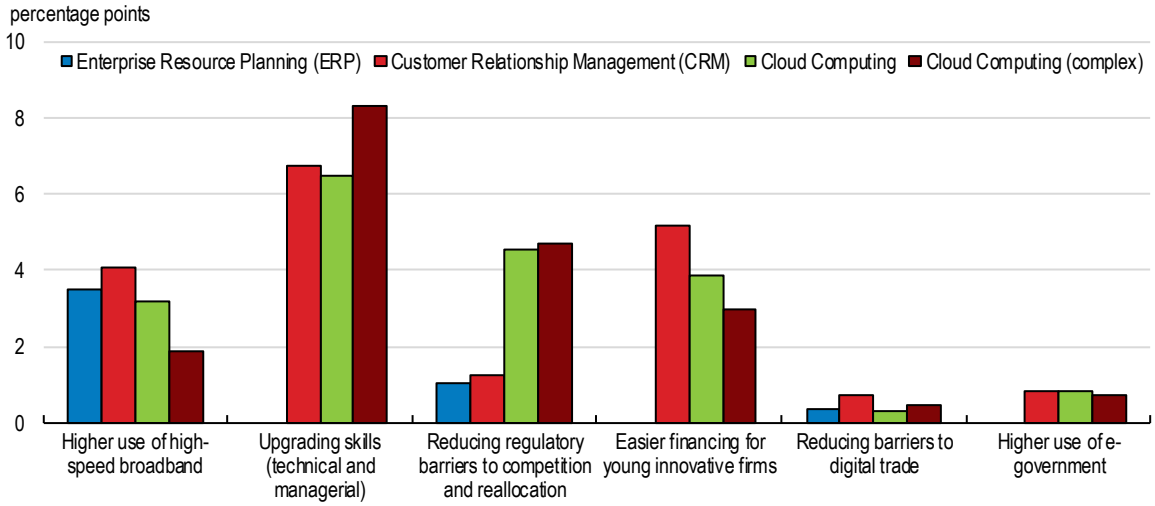
Note: "Frontier firms" is measured by the average of log labour productivity for the top 5% of companies with the highest productivity levels in each 2-digit industry and year. The "Non-frontier firms" lines capture the averages of the log-productivity distribution in each industry and year (excluding the top 5%). The values obtained for the detailed 2-digit industries are averaged to industry groups that are classified either as having "high" or "low" digital intensities according to the methodology in Calvino et al. (2018).

Source: Pareliussen and Mosiashvili (2020), based on Statistics Estonia annual bookkeeping reports database.

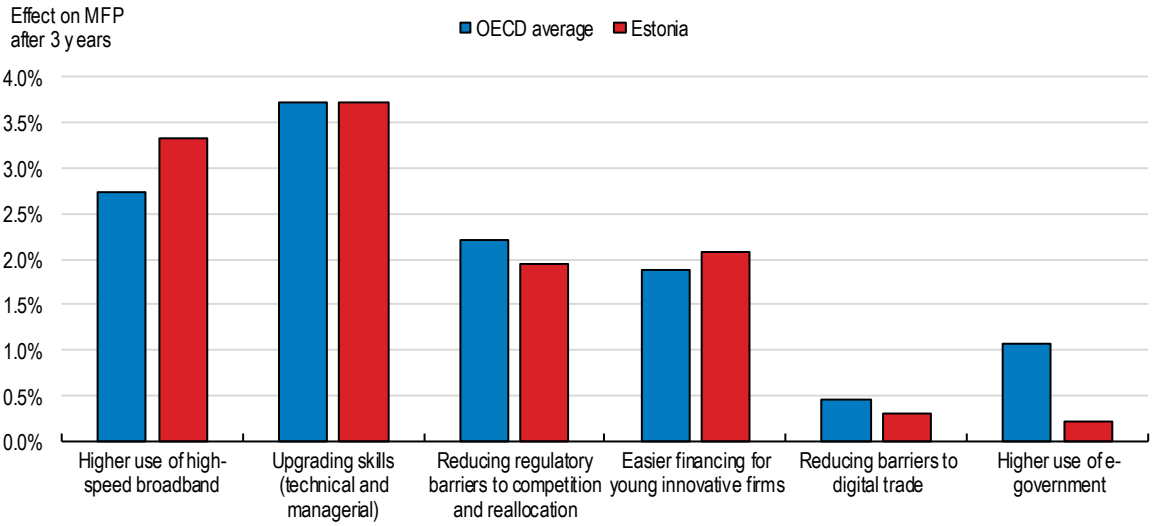
7. A previous wave of digitalisation, associated with the diffusion of personal computers, boosted productivity growth in the late 1990s. However, the current wave of digitalisation has not boosted productivity sufficiently to offset the cyclical- and structural headwinds to productivity mentioned above. Recent OECD work argues that digitalisation has supported productivity growth, but that the remaining potential to use digital technologies to boost productivity further is vast, notably by moving digital adoption rates in laggard firms closer to those of frontier firms. Increasing the up-take of high-speed broadband, upgrading skills, reducing regulatory barriers and easing financing are all associated with higher use of digital technologies, which in turn are associated with substantial productivity gains (Figure 5; OECD, 2019a; Sorbe, et al., 2019 Pareliussen and Mosiashvili, 2020).

Figure 5. The productivity potential from digital adoption is substantial

A. Association between policy factors and digital adoption in Estonia



B. Subsequent association with productivity



Note: Estimated association between the average digital adoption rate (Panel A) and the multi-factor productivity (MFP) of the average firm (Panel B) of a range of policy and structural factors (see Box 1 in Sorbe et al., 2019). The effect of "Higher use of high-speed broadband" on productivity combines direct and indirect effects. "Upgrading skills" covers participation in training (for both high and low-skilled), quality of management schools and adoption of High Performance Work Practices (HPWP). "Reducing regulatory barriers to competition and reallocation" includes lowering administrative barriers to start-ups, relaxing labour protection on regular contracts and enhancing insolvency regimes. "Easier financing for young innovative firms" covers the development of venture capital markets and the generosity of R&D tax subsidies. For each of the underlying indicators, it is assumed that half of the gap to the best performing country in the sample is closed and that policy factors in each group are largely independent from each other.
Source: Sorbe et al. (2019).

8. Estonia has sizeable digital strengths. It is a world leader of e-government, and the birthplace of a number of successful ICT start-ups, many of them now internationally renowned companies, such as Skype, Bolt (Taxify), FunderBeam and TransferWise. In contrast to the large number of world-class players in the ICT sector, traditional companies lag behind in the adoption of digital technologies. This paper argues that the potential of speeding up digital take-up outside of the ICT sector to boost productivity growth is considerable, and that the government can do more to facilitate a change of pace. First, supporting access to high-speed broadband and the stable and secure functioning of vital digital services and infrastructure lays the foundations for digitalisation in terms of physical access and trust among users. Second, ensuring high, up-to-date and equitably distributed skills and an adequate social safety net are central to both seizing the potential to automate, and to minimise the burden for those who are negatively affected. Third, the public sector is instrumental in creating a business-friendly environment, with regulations supporting business dynamism that allows human resources, capital and technology to find their most productive use as well as experimentation with new technologies and business models. Finally, realising the potential to boost productivity by means of digital technology adoption depends on the successful exploitation of complementarities; between different digital technologies; with firms' capabilities and assets, notably different types of skills; and with policies facilitating digitalisation and an efficient allocation of resources in society (OECD, 2019a; Sorbe, et al., 2019).

Better utilising productivity potential of advanced digital technologies

9. The productivity potential of embracing digitalisation is substantial in Estonia and elsewhere, and goes well beyond the productivity potential of adopting any single currently available technology. However, studies of existing technologies can illustrate potential gains. For example, increasing the sector-level adoption rate of Customer Relationship Management (CRM) front-office software by 10 percentage points is associated with a 1.7% productivity increase in the average EU firm. Cloud computing and Enterprise Resource Planning (ERP) back-office software each adds an average of approximately 1%, when implemented in isolation (OECD, 2019a; Gal et al., 2019).

10. However, digital technologies are complementary to each other. Cross-country regressions indicate that boosting high-speed Internet connections (30Mbit/s) by 10% would boost productivity directly by 2% in Estonia, while indirect effects from increased adoption of cloud computing, ERP and CRM would add another 1.5% to the productivity increase (Sorbe et al., 2019). Combining different digital technologies, for example back-office and front- office automation, can also yield considerable gains. In addition, complementarities with other firm assets, such as skills and organisational practices, are illustrated by the finding that those firms who were most productive in the outset were also those gaining the most from adopting new digital tools (Gal et al., 2019).

11. Finally, in addition to boosting productivity in adopting firms, the adoption of digital technologies and digital skill use generate sizeable spill-over effects in Estonia. For example, increasing a measure of overall digitalisation by one standard deviation is associated with 2.1% higher productivity in the adopting firm. However, if the average firm in the sector increases its level of digitalisation by a standard deviation, the average productivity gain increases to 7.5% (Box 1).

Box 1. Firm- and sector-level productivity gains from digital technology adoption in Estonia

Recent OECD work, notably Gal et al. (2019) and Sorbe et al. (2019), have shown substantial firm-level productivity gains associated with higher average rates of digital adoption in the sector to which the firm belongs. The structure of the data did not allow these studies to disentangle direct effects on the firms actually adopting the technologies from indirect effects of belonging to a sector with high digital intensity. New OECD research, resting on a unique firm-level dataset combining various survey- and registry data from Statistics Estonia covering 2700 firms in 10400 observations, sheds new light on this question. Each firm-level variable measuring technology adoption, digital skill use and training are decomposed into sector averages and individual firms' difference to their respective sector averages. The former measures between-sector associations with productivity growth, while the latter measures within-sector (between-firm) associations. Assuming causality, within-sector effects can be interpreted as the direct productivity boost from adopting firms, while sector effects can be interpreted as sectoral spill-overs linked to growth at the sectoral productivity frontier and non-frontier firms learning from the innovations and good practices of frontier firms. The results show that the firm-level productivity growth premium of being an adopting firm is consistently positive and sizeable across different digital technologies and measures of skill intensity. The overall productivity growth of the private sector is on the other hand dominated by positive spill-over effects of digitalisation, concentrated in manufacturing industries (Table 1).

Table 1. The productivity premiums from digital adoption and skill use are substantial

Percent difference in annual labour productivity growth associated with digital adoption/ digital skill use

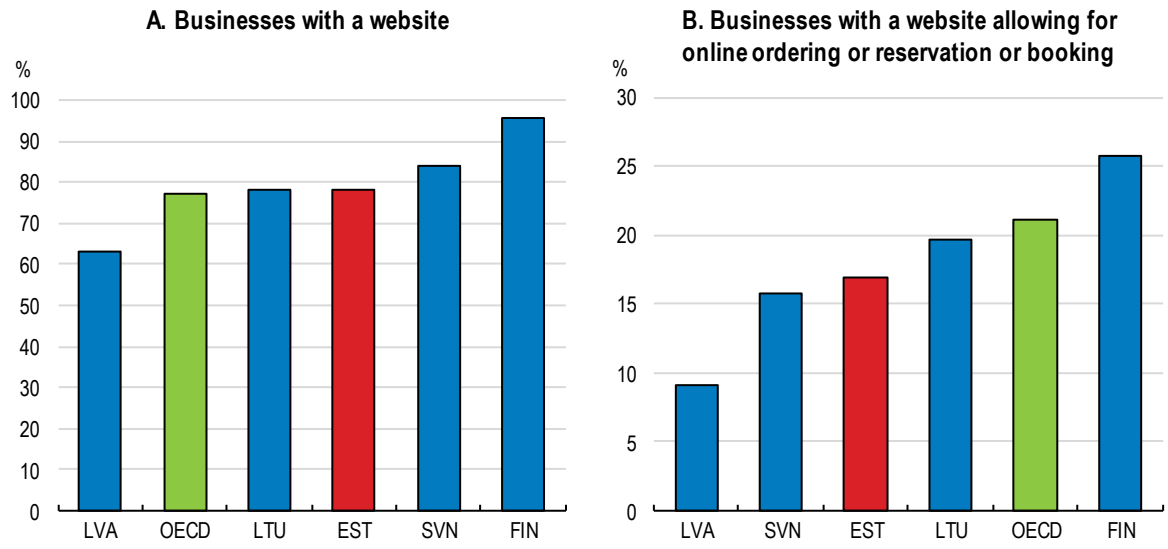
	High-speed broadband	ERP software	CRM software	Digital skill use intensity	ICT training
Adopting firm perspective					
Direct effect	3.71	2.90	3.80	4.62	5.00
Sector perspective					
Direct effect	0.33	0.37	0.57	3.18	0.58
Sector spill-overs	0.95	1.01	2.02	3.25	2.56
Sector total	1.29	1.38	2.59	6.43	3.13

Note: The data and methodology do not allow a causal interpretation of the results. The results are calculated in seven individual regressions because of high correlations between the different digital adoption and skill-related variables. The results are therefore not cumulative. Adopting firm perspective: For digital skill use intensity (the share of employees using computers for work purposes), the adopting firm is assumed to increase adoption/skill use with one standard deviation (within sector). For ICT training, broadband, ERP and CRM, which are all binary variables, firms are either adopters or non-adopters. Sector perspective: The sector average and spill-over effects are calculated for a one standard deviation (between sector) increase and scaled by manufacturing's share of total net profits in the sample (approximately 47%) to arrive at an estimate of the average effect for the total sample. The columns show (re-scaled) results for firm-level dummy variables of the adoption of broadband (>30Mbit/s), ERP software, CRM software and the provision of ICT training to its employees, as well as the share of employees using computers for work purposes. Calculations are based on regression coefficients from Pareliussen and Mosiashvili (2020), all of which are significant at least at the 95% level. Data cover the years 2011-2016.
Source: Pareliussen, J. and N. Mosiashvili (2020), *"Digital technology adoption, productivity gains in adopting firms and sectoral spill-overs – Firm-level evidence from Estonia"*, OECD Economics Department Working Papers, OECD Publishing, Paris, forthcoming.

12. Estonian companies lag behind the OECD average in realising the productivity potential from using advanced digital tools. For example, most have their own website, as in the average OECD country (Figure 6, Panel A), but they use websites mainly to disseminate information about the firm, not for uses with the potential of enhancing productivity further, such as interacting with customers. Fewer firms have

websites equipped with functions for online ordering or booking than in the average OECD country, let alone high-performers, such as Finland (Panel B).

Figure 6. Many firms have own websites, but their functionality is rather limited



Note: % of enterprises with 10+ employees, 2018.
Source: OECD ICT database on business usage.

Digital foundations are strong

13. The relative weakness in digitalisation of the non-ICT businesses sectors contrasts with an ICT sector with considerable strengths, and Estonia's reputation as a front-runner in e-government. Solid digital foundations, notably physical access to high-speed broadband and trust among users nurtured by stable and secure vital digital services and infrastructure, are necessary enablers for digital technology diffusion (OECD, 2019c).

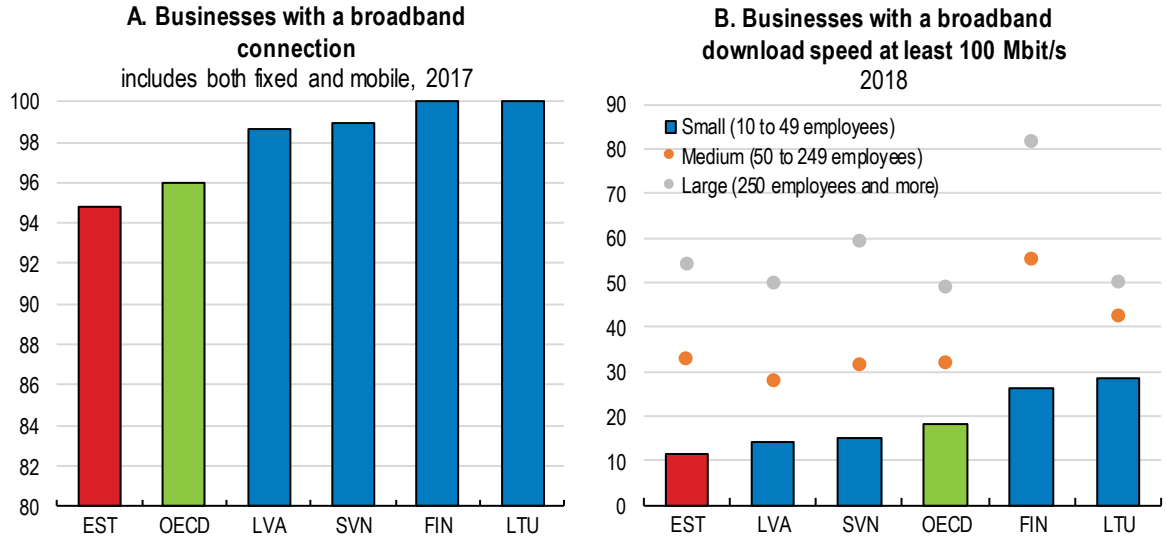
Broadband infrastructure is of high quality, but under-utilised by companies

14. Infrastructure, in particular businesses' access to high-speed broadband, is a prerequisite to the adoption of digital technologies. In Estonia, companies using high-speed broadband connections (30Mbit/s or higher) see 3.7% higher productivity growth than others (Pareliussen and Mosiashvili, 2020). The Estonian backbone broadband network is of high quality, and current efforts to complete the deployment of the middle-mile network of fibre-optic cables will see 98% of all residential buildings, companies, and public authorities located within 1.5 km of at least one fibre-optic network access point with speeds of at least 100Mbit/s by 2020 (Government of Estonia, 2018). This effort also raises broadband coverage in Estonia at any speed, which was lower than the European Union average in 2018. The last-mile network may still hold back connection speeds in some locations, despite on-going efforts to connect at least 100 000 additional addresses, 40 000 of which with government support (European Commission, 2019a). Therefore, government subsidies for last-mile connection, in particular for small and medium-size enterprises are justified. Such subsidies should be based on thorough cost-benefit analysis.

15. Take-up of high-speed broadband is relatively low in Estonia despite high-quality infrastructure. In 2018, 83% of households were covered by broadband connections of 100Mbit/s or faster, considerably

above the EU average of 60%, but the take-up was only 11% (European Commission, 2019a). Most companies have a broadband connection (Figure 7, Panel A), but few have ultra-fast connections of at least 100Mbit/s, especially among small- and medium-sized firms (Panel B). Realising a productivity boost from high-speed broadband access depends on firms actually connecting at higher speeds, but firms' connection speeds lag way behind the potential. Making small- and medium-sized companies realise the benefits of a fast connection matters, since small firms (10-49 employees) in the manufacturing sector have a joint turnover about triple that of big firms (250 employees or more). However, benefits can only be fully realised when combined with investment in digital technologies and organisational capital (Fabling and Grimes, 2016).

Figure 7. Most firms have a broadband connection, but not ultra-high speed



Source: OECD ICT database on business usage.

E-government and core digital infrastructure excel globally

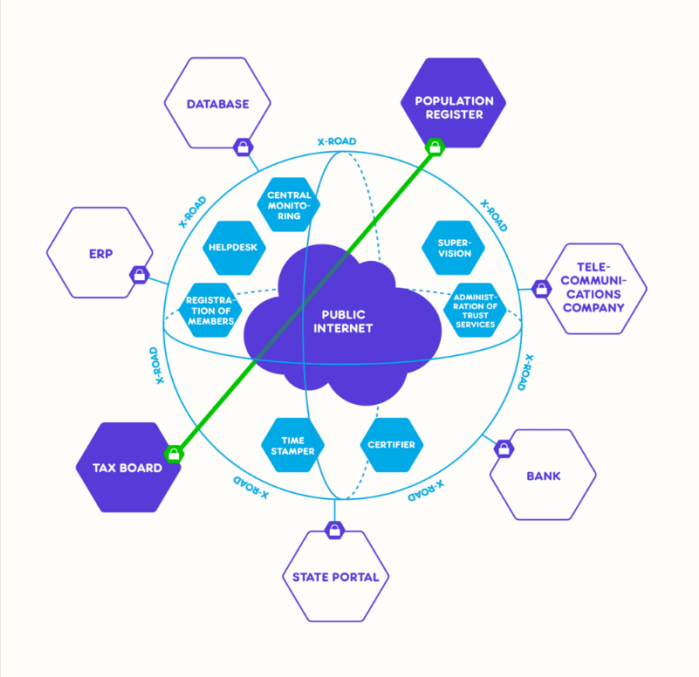
16. Estonia has been a frontrunner in digitising government services and by now all but three public services (marriage, divorce and real estate transactions) are securely delivered online (Box 2). Digitalisation of public services has been an important tool to build trust in the public sector after a tumultuous period following re-gained independence in 1991. The X-road, the communication- and encryption protocol at the centre of Estonia's e-government, in combination with the Estonian digital ID, provide secure, transparent and traceable encrypted communication between public and private service providers and individuals.

17. Online availability of government services in Estonia ranked second in the European Commission's e-government benchmark after Austria in 2017, exceeding even Finland (Figure 9, Panel A). Mobile applications, however, lag behind top performing countries (Panel B), and take-up is low. Greater availability of government services on mobile phones would probably increase uptake rates.

Box 2. E-Estonia

The building of e-Estonia started soon after the country's independence. Estonia's success in e-government depends crucially on two features, which to this day are missing in some OECD countries: One (or more) secure digital ID(s), commonly accepted by service providers, and a secure, commonly accepted communication protocol, such as Estonia's X-Road (Figure 8). In 1994 the Information Policy Law was passed and the Data Protection Department created. A following major milestone was the Digital Signatures Act in 2000, which allowed a number of government services requiring signature to go online. The same year marked the start of digital tax filing and paperless cabinet meetings. E-filing of personal income tax returns reached 95% as early as in 2013, ranking among the top third in the OECD. An even greater share of corporate income taxes and VAT were filed online and by now all those have gone paperless. In 2002 the e-ID card was introduced, which considerably simplified the way Estonians interact with the government. The e-health system was established in 2008, two years later e-prescriptions became available.

Figure 8. The X-Road platform for secure data sharing



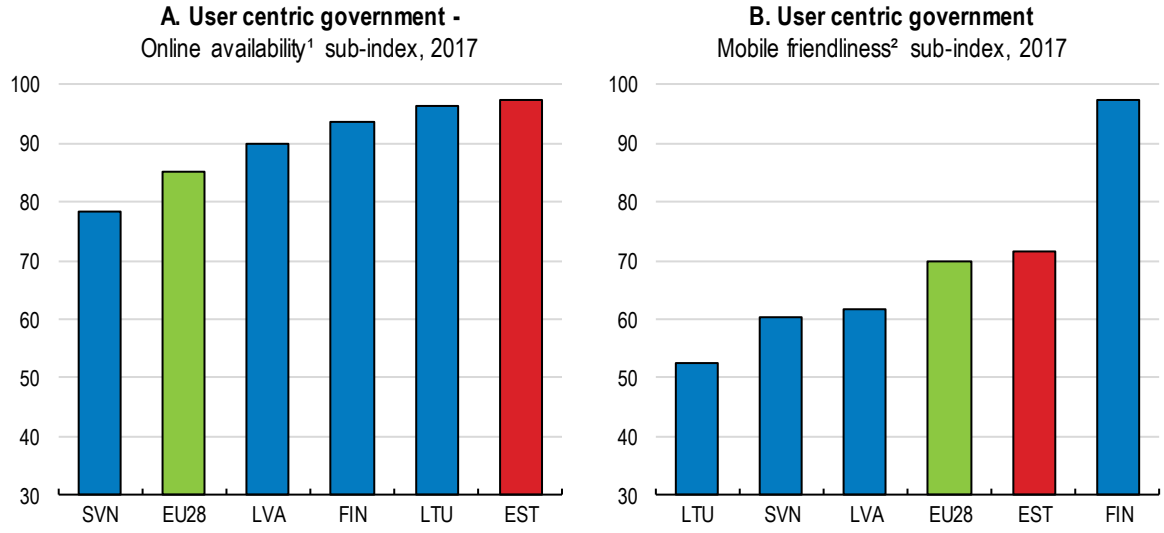
Source: X-Road (website, x-road.global) Nordic institute for interoperability services.

Data security is achieved by state-of-the-art technologies outsourced to the private sector through procurement contracts. Personal data in Estonia are not stored on a single server but at various data registry points, interlinked through the X-Road (introduced in 2001), a platform for secure data sharing, with all incoming and outgoing transactions authenticated and encrypted. X-Road does not build on blockchain technology, but similar to blockchain it secures traceability through a distributed ledger, meaning that any transaction or information access will be recorded in several places. Citizens can monitor the time and access point of their data files through the government service portal www.esti.ee.

A major principle of the system is single sourcing of data, for instance, the population registry is in charge of recording home addresses and all such queries will end up there. The use of digital signatures in Estonia is estimated to save 2% of GDP every year. The cost of e-voting, for instance is a mere 2 euros per vote, versus 6 euros in the case of paper-based voting.

Source: E-Estonia Guide (2018) and OECD (2015).

Figure 9. Online availability of government services is high, but could be more mobile friendly



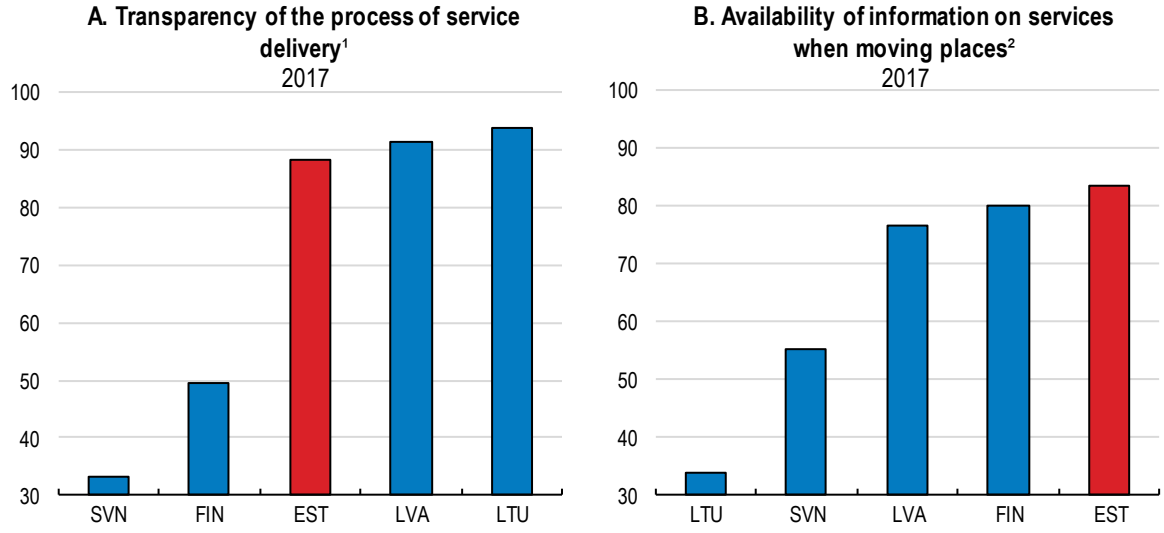
Note: 1. The top-level benchmark user centricity (to which both the online availability and the mobile friendliness sub-index belong) indicates to what extent (information about) a service is provided online. Online availability: indicates if a service is online. Ranging from offline (0%), only information online (50%), fully online (100%).

2. Mobile friendliness: indicates if the website provides a service through a mobile-friendly interface, an interface that is 'adopted' to the mobile device.

Source: European Commission eGovernment Benchmark 2018.

18. Government e-transparency is high. It is relatively easy to find information on government services and on how the government is organised (Figure 0.10, Panel A). Estonia also scores high on the access to online information in case, for instance, of moving places (Panel B). Furthermore, it is a frontrunner in cross-border availability of online services, thereby contributing to the creation of the European Single Digital Market. Estonia also collaborates with Finland in the form of automated exchange of information about citizens moving from one country to the other. This prevents double payment of social security contributions and the mutual use of health care systems.

Figure 0.10. Government services are transparent and cover a wide range



Note: 1. The top-level benchmark Transparency indicates to what extent governments are transparent. Transparency of service delivery: indicates to what extent governments are transparent as regards the process of service delivery.

2. The top-level benchmarks for Citizen and Business Cross-border mobility indicates to what extent EU citizens can use online services in another country. Online availability: indicates if a service is online. Ranging from offline (0%), only information online (50%), fully online (100%).

Source: European Commission eGovernment Benchmark 2018.

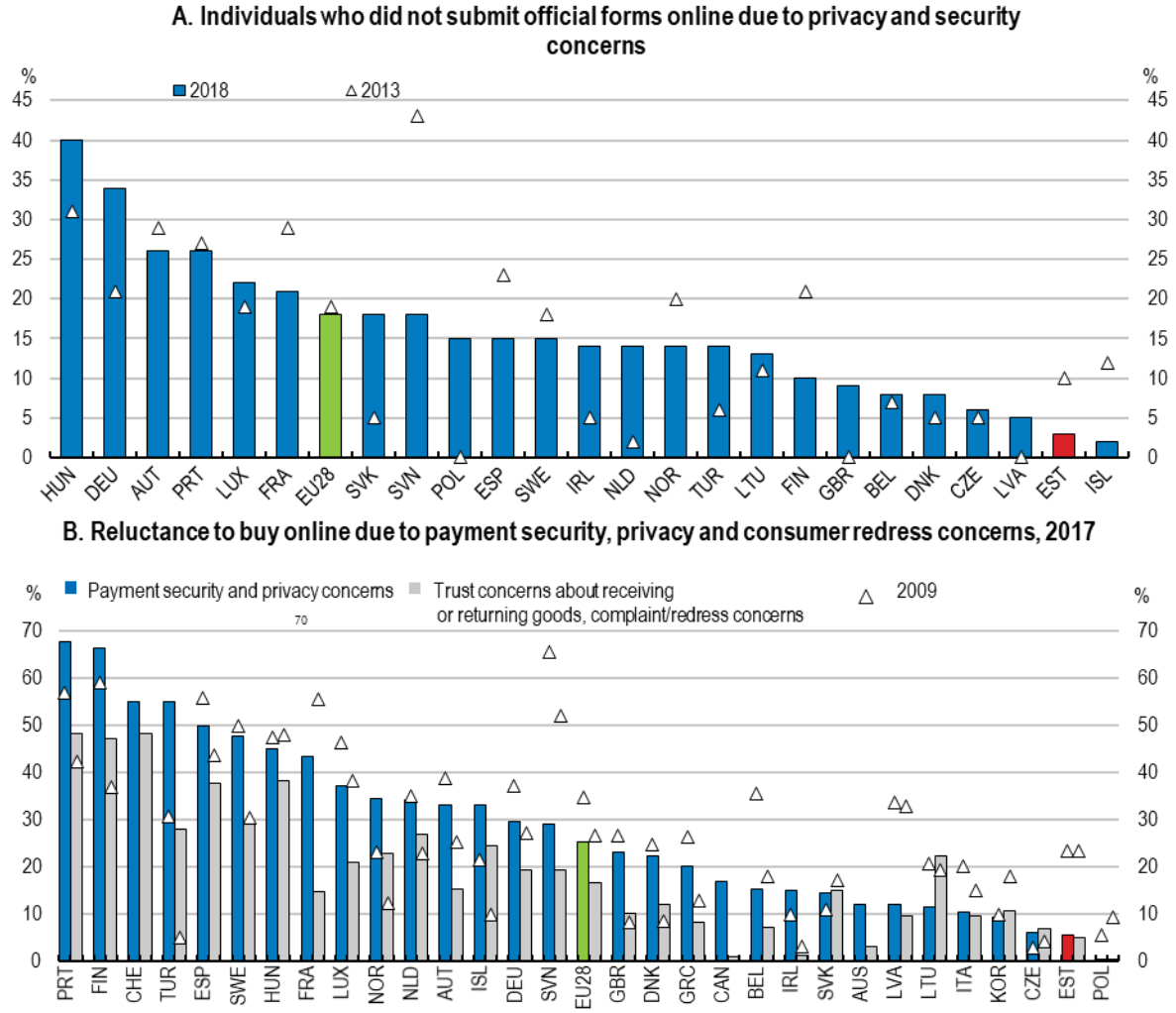
Security in key digital systems is high, but users should be more aware

19. A high level of digital security helps build the trust necessary for individuals, firms and the public sector to fully embrace digital solutions, and thus unleash their full productivity potential. Keeping the digital infrastructure and digital services secure becomes increasingly important, as an increasing share of service delivery and communication happening online raises the potential costs of security breaches. Vital services like rescue, electricity and water supply, phone and data communication, currency circulation, payment services and personal identity management increasingly rest on digital foundations (Praxis, 2019b), and adverse events to critical digital infrastructure can potentially have significant economic and social consequences.

20. Estonians have high trust in public digital services, and they trust key infrastructure to access private services online, such as payment solutions (Figure 11). Their trust is to a large extent warranted, as the country is a forerunner in the field of digital security, with a high level of expertise and good systems for coordination within different arms of government and key actors in the private sector (Box 3).

Figure 11. Estonians trust key online services

Individuals who did not submit official forms online due to privacy and security concerns, 2018



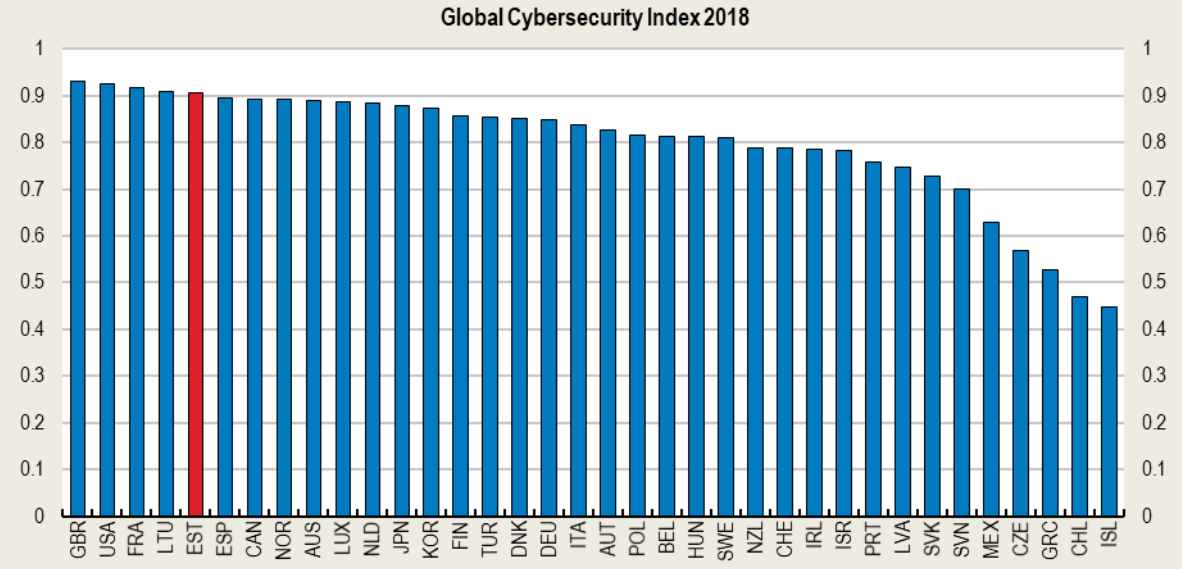
Note: The share of individuals who did not submit official forms online due to privacy and security concerns is calculated as a share of individuals who chose not to submit official forms online for any reason (shown on top of bars).

Source: OECD (2019e), Measuring the Digital Transformation: A Roadmap for the Future.

Box 3. Estonia – a Digital Security forerunner

Estonia is a forerunner in the field of digital security, ranking 5th in the Global Cyber Security Index 2018 (Figure 12). Estonia's cyber security capabilities, built up in parallel with its push for e-government, was put to the test during a massive cyber-attack targeting critical digital infrastructure in 2007. Except from approximately one and a half hour downtime on a number of public and private services, the integrity of the system was not compromised. The incident led to a renewed effort to secure the digital infrastructure, and in 2008 Estonia was one of the first countries in the world to issue a national cyber security strategy that recognised the interdisciplinary nature of cybersecurity and the need for coordinated action in the area. (Ministry of Economic Affairs and Communications, 2019).

Figure 12. The security of vital digital services is high



Source: International Telecommunication Union (2019), Global Cybersecurity Index 2018.

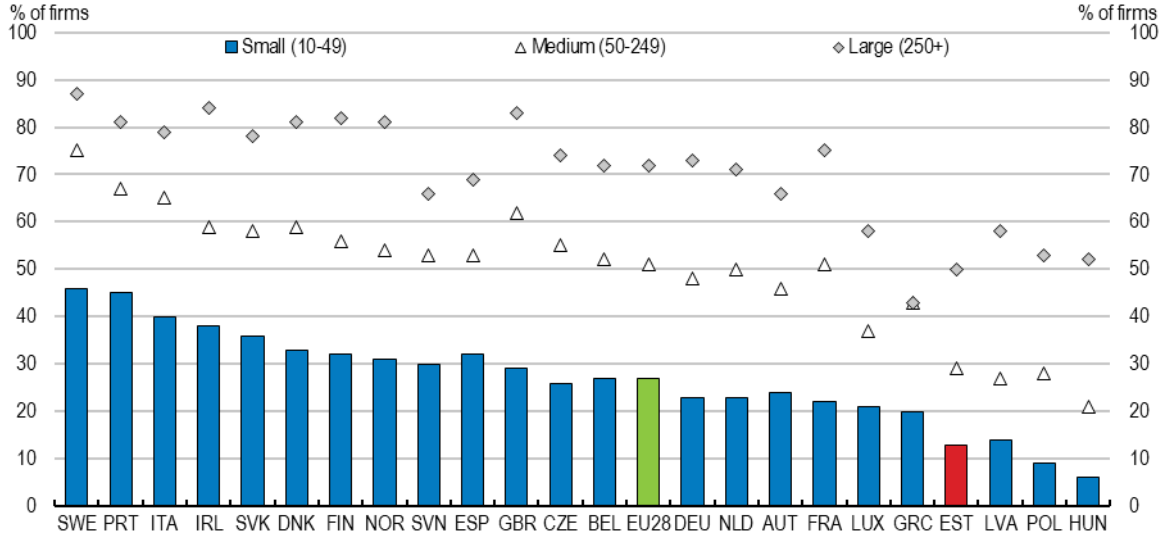
Estonia has a well-developed system to coordinate cyber-security across government and with the private sector. The civilian arm of digital security is organised under the Ministry of Economy and Communications, with the operational responsibility to maintain the civilian digital infrastructure delegated to the Estonian Information System's Authority. The Authority maintains close coordination with the Estonian Foreign Intelligence Service (under the Ministry of Defence) and the Estonian Internal Security Service (under the Ministry of the Interior) through the national Cyber Security Council, chaired by the Secretary General of the Ministry of Economic Affairs and Communications. The Council reports directly to The Government Security Committee, chaired by the Prime Minister. The Cyber Security Council coordinates with all relevant ministries, and maintains a network of Chief Information Security Officers from companies and state agencies that provide or oversee critical services. Estonia also plays a central role in international cooperation in the area, as host to the NATO Cooperative Cyber Defence Centre of Excellence in Tallinn (Ministry of Economic Affairs and Communications, 2019).

21. Even though the digital infrastructure and critical public and private services are well-protected, managing digital security risks is not just a matter for the public sector and private providers of vital services. It is the responsibility of everyone online, and there are still gaps among firms and individuals.

Having a formally defined digital security policy is a sign of taking a pro-active approach to digital security. However, the average Estonian company lags behind the average country also in digital security, regardless of firm size (Figure 13).

Figure 13. Digital security lags behind in many companies

Enterprises having a formally defined security policy, by size, 2015

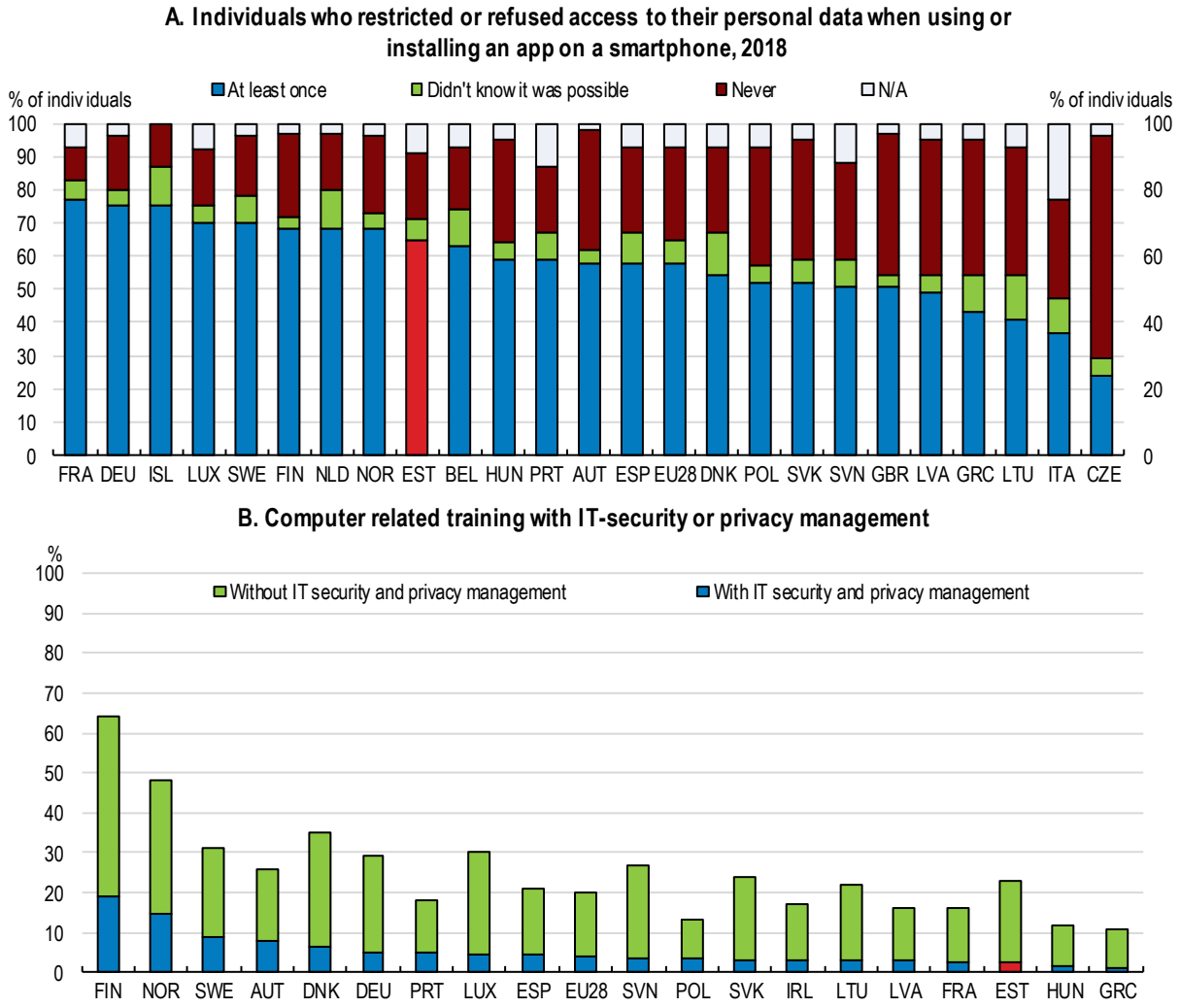


Source: OECD (2019f), Measuring the Digital Transformation: A Roadmap for the Future.

22. The incidence of having restricted access to personal data when using or installing an app is a measure of peoples' awareness over IT security and privacy issues. Estonia is doing better than the EU average, but a large share of internet users are still either unaware or passive (Figure 14, Panel A). This points to the need to raise skills and knowledge on cyber security beyond public and private providers of critical infrastructure and services, both by boosting the number of cyber security specialists and by increasing skills and awareness in the general population.

23. In order to meet demand, cyber security should increasingly be offered in universities and vocational schools, both as part of the curriculum in ICT specialist education, but also in free-standing courses available to non-specialists. Digital security and privacy risk management in cyber space should also be included in teacher training together with elementary digital skills, and integrated in compulsory education (Praxis, 2019b). Including security and privacy issues in existing digital training initiatives should also be prioritised, as the share of internet users who have received such training is low, both in absolute terms, and as a share of those attending any ICT related training (Panel B). These issues are on the government's agenda. The Lifelong Learning Strategy 2014-2020 stipulates that competences pertaining to digital skills should also include cybersecurity, and that besides digital technology, elementary knowledge related to cybersecurity should be integrated into curricula (Ministry of Economic Affairs and Communications, 2019).

Figure 14. Individuals' digital security awareness and skills need further strengthening



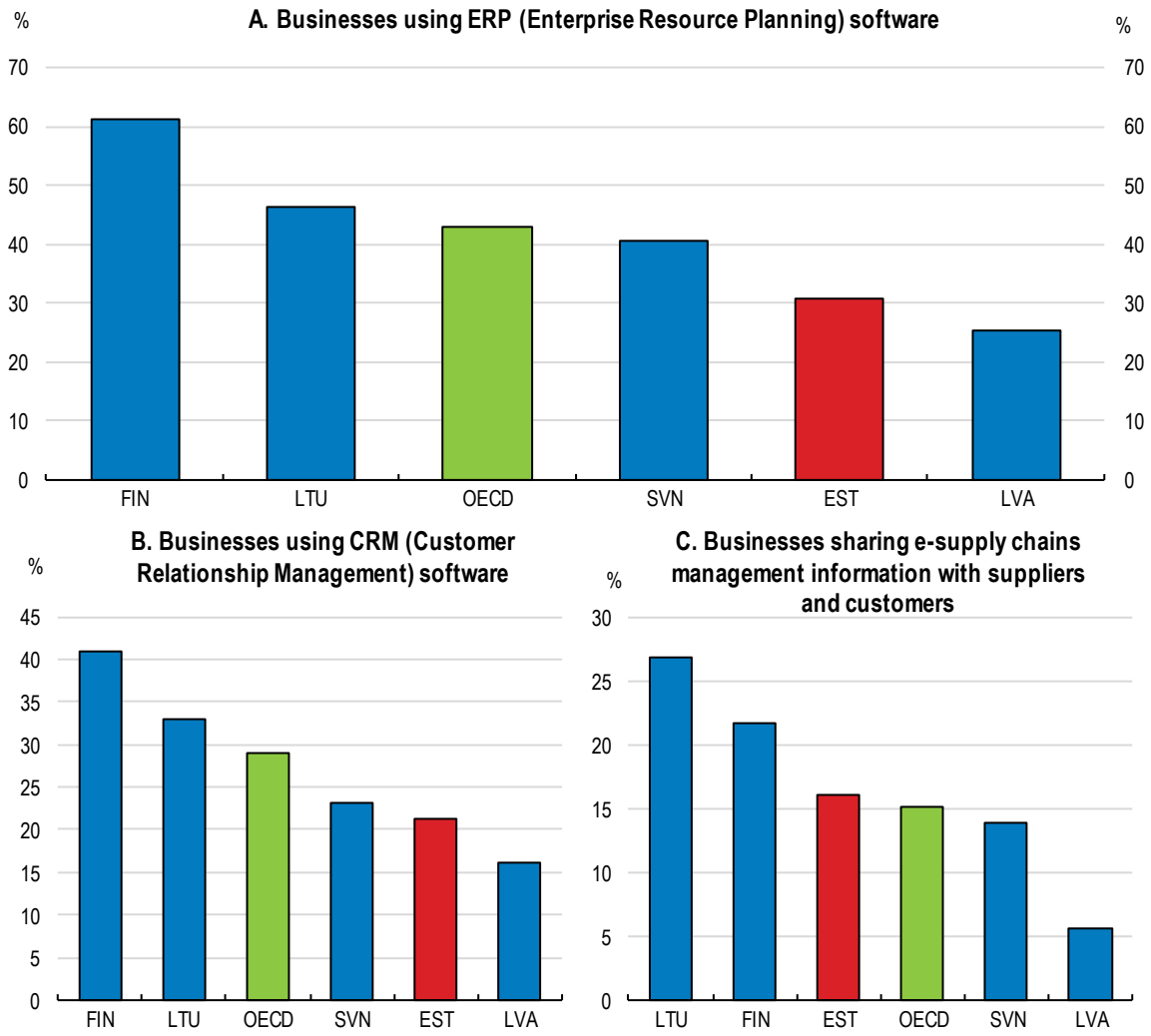
Source: OECD (2019f), Measuring the Digital Transformation: A Roadmap for the Future; Eurostat, Digital Economy and Society Statistics, Comprehensive Database.

Estonian companies lag behind peers in the adoption of digital technologies

24. Despite solid and secure digital infrastructure, world-leading e-government and high levels of trust among users of digital services, Estonian companies lag behind companies in other OECD countries, also Central and Eastern European economies such as Slovenia or Lithuania, in the use of several digital technologies, such as ERP and CRM software (Figure 15), Panels A and B). Estonian manufacturers are slightly more frequent users of supply-chain management software than the OECD average, but well behind their Lithuanian counterparts (Panel C). Roughly 20% of Estonian firms use e-sales, on par with the EU average. Approximately one-third of Estonian companies with 10 employees or more use cloud computing. This is also around the OECD average, with small companies doing relatively better and bigger ones relatively worse compared to the OECD average. Estonian companies tend to use cloud computing for back-office functions such as accounting and office services, rather than for customer-oriented services, such as customer relationship management, which is considered a major bottleneck of Estonian firms by business associations.

Figure 15. Estonian enterprises need to adopt more digital tools

Manufacturing, 2017 or latest available



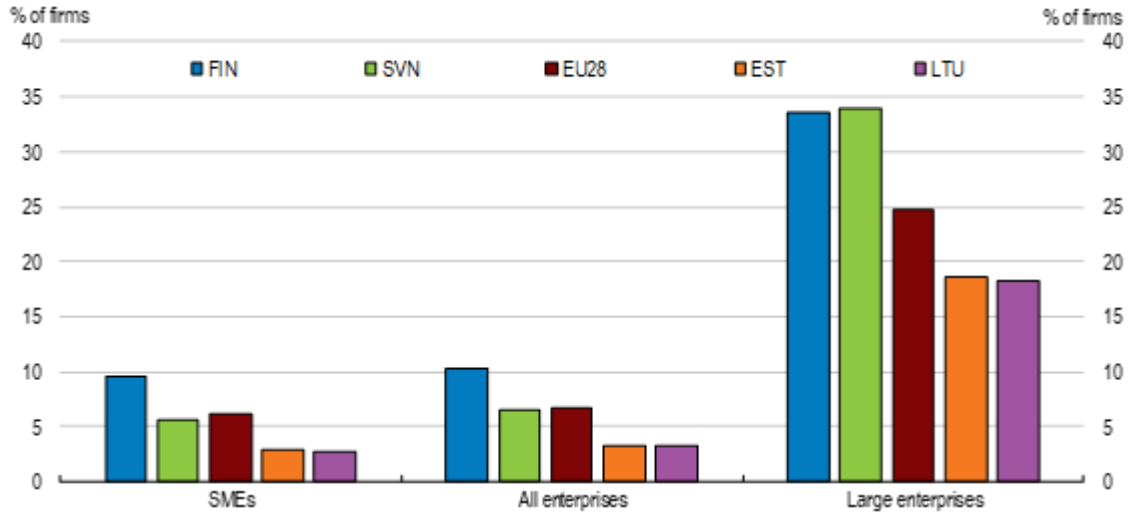
Note: OECD average is the simple average of 29 members not including Australia, Chile, Israel, Japan, Mexico and the United States, for which data were not available. Firms with at least 10 employees.
Source: OECD ICT Use by Business database.

25. These are only a sub-set of available technologies, and emerging digital solutions will improve, complement and in some cases replace existing ones. ERP for example, has brought considerable efficiency gains by automating many back office functions related to technology, services and human resources, and is associated with high productivity growth in Estonian firms (Pareliussen and Mosiashvili, 2020). However, automation and digitalisation of processes beyond ERP are now being implemented. For instance, feed-in of customer data changes or planned delivery time adjustments are now simpler owing to new ICT solutions. Since the technology frontier is shifting constantly, it is important to embrace new digital technologies, such as the Internet-of-things, big data and artificial intelligence (AI). These technologies use data to enable more nimble, customer-centric and hence productive business models. The share of firms with at least 10 employees using big data is slightly over 10%, somewhat lower than

the OECD average. It is, however, higher than any other Central and Eastern European OECD country, except Lithuania.

26. Automation is key to boost productivity, but less than 5% of Estonian firms use industrial or service robots, and less than 20% of firms with over 250 employees automated their production (Figure 16), which is among the lowest shares in the European Union. This may be related to the relatively low share in Estonia of vehicles and electronics industries, which tend to be highly automated elsewhere.

Figure 16. The use of robots is particularly low among SMEs



Note: Firms with at least 10 employees.
Source: OECD ICT Use by Business database.

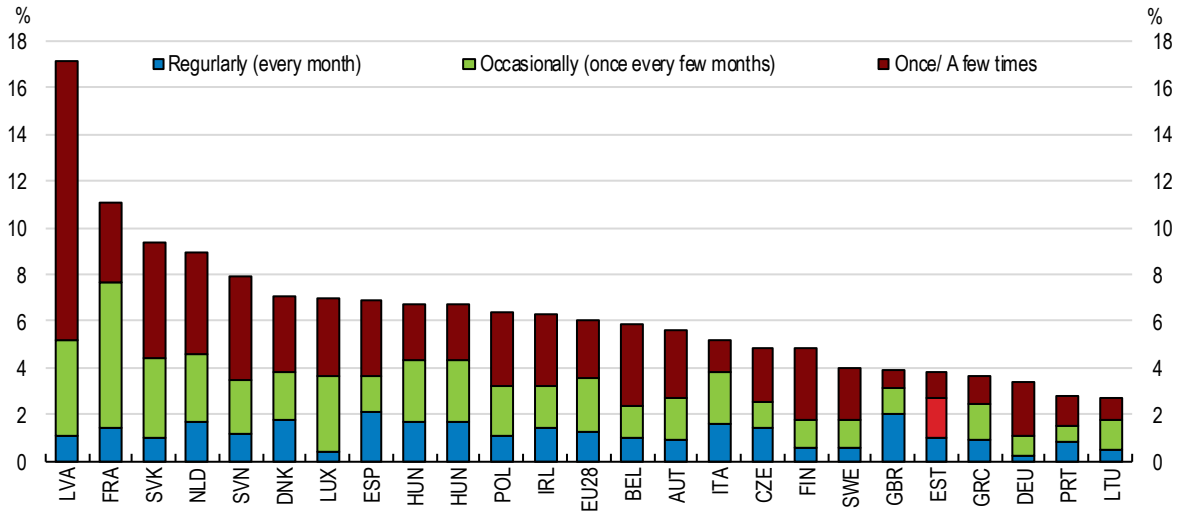
27. Digital aggregator platforms can increase productivity for other firms, including low-tech ones. Platforms can for example reduce information asymmetries between service firms and consumers, with user ratings and reviews, incentivising service providers to offer better value for money. They can widen market access, thus giving productive firms more opportunities to grow. Furthermore, platforms can bring efficiency gains to service providers by taking care of and rationalising side-activities, such as managing bookings and processing payments. They can enhance capacity utilisation (e.g. hotel occupancy rates) by improving matching efficiency and making the real-time availability of services easily visible online (OECD, 2019a). Cross-country empirical analysis in four industries (hotels, restaurants, retail trade and taxis) suggests that platform development has enhanced the productivity of existing service firms over the past decade. Platforms were found to boost productivity in existing service firms in four industries (hotels, restaurants, retail trade and taxis) by about 0.4% every year over 2011-17 for the average firm in France, Italy, Spain, the United Kingdom and the United States, countries experiencing relatively fast platform development (Schwellnius et al., 2019).

28. On the other hand, platform workers may be classified as self-employed and/or work irregular hours, and this can lead to gaps in social protection coverage. This can be mitigated by including workers that sit on the border between dependent and independent forms of work in the standard social protection scheme and by increasing income security for those working flexible hours (OECD 2019d; OECD, 2018c). Making the most of platforms can also be a way to ease social strain, since platforms offer flexible work with low entry thresholds (OECD, 2019a). In general, individuals connected to the internet and with higher digital skills are less likely to be unemployed, as digital technologies improve matching between employers and workers (Männasoo et al., 2020). The use of platforms is low in Estonia, albeit increasing, indicating that there is a considerable untapped potential (Figure 17). Regulations should be conducive to platform

work and allow experimental business models, for example with regulatory sandboxes, while also addressing potential negative effects on platform workers.

Figure 17. A low but increasing share of the population participates in platform work

Share of individuals aged 15 and over having ever offered services on platforms in the EU in 2018.



Source: The use of collaborative platforms, Flash Eurobarometer No. 467, September 2018.

29. Catching up with the OECD frontier is one way to reap productivity gains through digitalisation, however, there are also leapfrogging opportunities to exploit by embracing new digital industries. In general, Estonian firms seem to have been slower to adopt the most recent wave of digital technologies, which enable data-intensive e-services. To jump on the digitalisation bandwagon and leapfrog ahead others, the experience of some economies outside of Europe may serve more as a model. Some latecomers, for instance, China, have successfully embraced new digital industries by creating an enabling environment for new industries and heavily investing in digital infrastructure and by now have become global frontrunners.

30. In AI patent applications, three Asian economies and the United States are the leaders (Cornell University et al., 2019). While the size of the country matters for the absolute size of digital industries, adoption rates of new technologies can leap ahead of others if boosted by supportive policies. The relative ease of access to data for research purposes in Estonia should foster the adoption of AI. Estonia ranks above the average EU member in McKinsey's AI readiness index, which measures where countries stand across a range of AI enablers, including the number of AI start-ups per capita, automation potential of job activities, digital maturity, the availability of scientists and engineers, ICT business model creation, R&D expenditure, and ICT connectedness (McKinsey Global Institute, 2019).

The ICT sector is dynamic, but has room for improvement

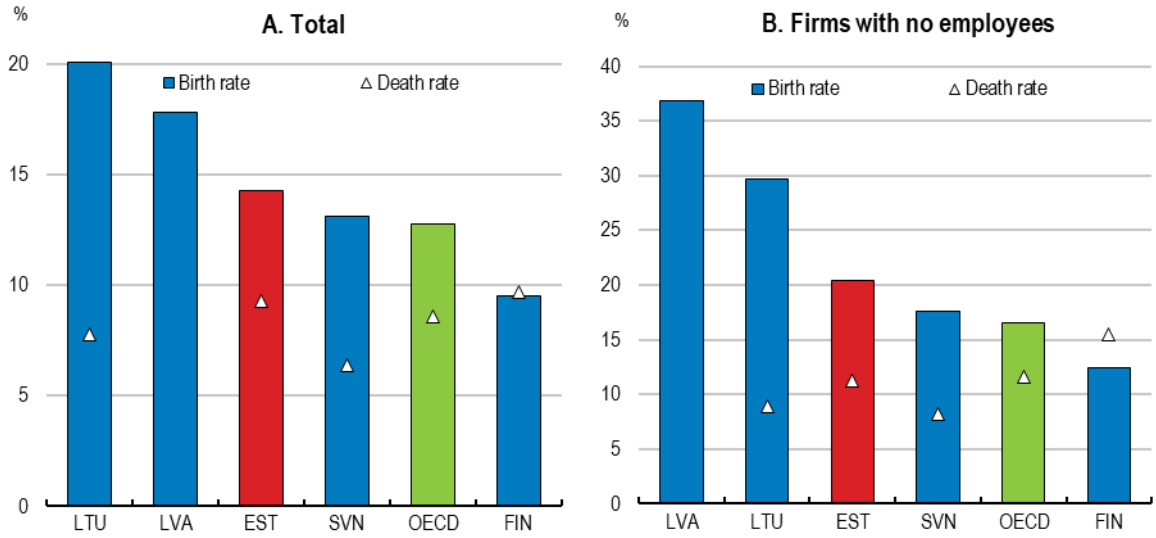
31. While several measurement issues surround the digital economy, a key indicator affecting its potential is the state of the ICT sector. Estonia's ICT sector has several strengths, although there is room for improvement along some dimensions.

32. A major strength of the Estonian ICT sector is its creativity (which does not show up in its patenting output as most of its innovations are not patentable), which should be a building block for future digitalisation. Estonia is home to a number of successful ICT start-ups, many of them are now

internationally renowned companies. Several of those digital native companies have achieved unicorn (i.e. a privately held start-up company valued at over USD 1 billion) status and there are three Estonian companies in the Financial Times 2019 list of Europe's fastest growing 1000 companies. One of the two technology companies in the list (the third belonging to chemicals) ranks third with an over 12 000% revenue growth. These companies tend to operate on a global scale, with head offices overseas and likely with limited spill over effects on the Estonian economy.

33. The ICT sector, in general, is dynamic, with high firm creation rates in ICT services are coupled with high destruction rates (Figure 14.A). Sole proprietorships (firms with no employees) in the sector are popping up at high rates and they are similarly disappearing fast (Figure 2.14.B). The creation of micro firms (with 1-9 employees) in ICT services, however is not that spectacular, just above the OECD average and well below not only the United Kingdom, but also several Central Eastern European economies, such as Hungary or Poland.

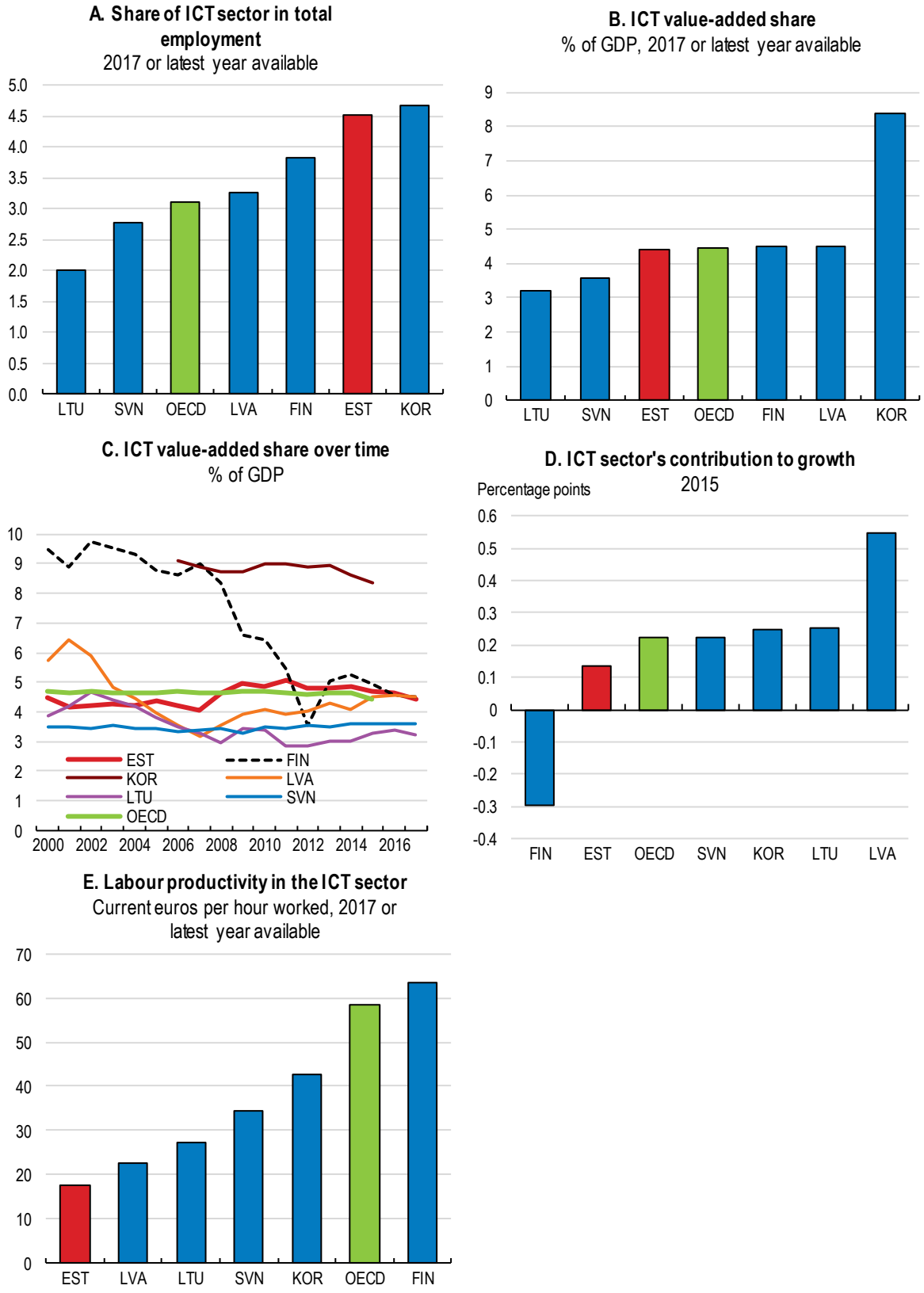
Figure 18. Business dynamics in ICT services are strong, 2016



Note: ICT services are produced in sectors 58-63: Information and communications according to the ISIC Rev.4 classification. The OECD average is without Canada, Chile, Colombia, Japan, New Zealand, Mexico and the United States, for which no comparable data were available. The birth rate is the ratio of newly created firms in the given year to the number of already existing firms, while the death rate is the ratio of firm closures in a given year to the number of existing firms.
Source: OECD SDBS Business Demography Indicators (ISIC Rev. 4)

34. However, on a number of measures, the Estonian ICT sector lags behind frontrunners, especially if looking on a global scale. The ICT sector (comprising both manufacturing and service industries) is a relatively big employer in Estonia, just like in Korea, a global digitalisation frontrunner (Figure 13.A). High employment in the ICT sector has the potential of skills spill-overs to other sectors through job changes, but currently, few ICT staff look for opportunities in other sectors. The ICT sector's value added share, however, is about the half of Korea's (Figure 13.B). As Estonia has already branded itself as highly digitalised in government services, when setting objectives for the business sector, it is more useful to look at global frontrunners, such as Korea. Moreover, the ICT value added share has been slightly shrinking since the Global Financial Crisis (Figure 9.C). The ICT sector in Estonia contributes to growth less than in an average OECD country (Figure 13.D). Furthermore, labour productivity, which is an important measure of its competitiveness, is not particularly high in the ICT sector, not only compared to advanced, but also to several Central and Eastern European economies (Figure 13.E).

Figure 19. ICT sector performance is comparable to that in peers

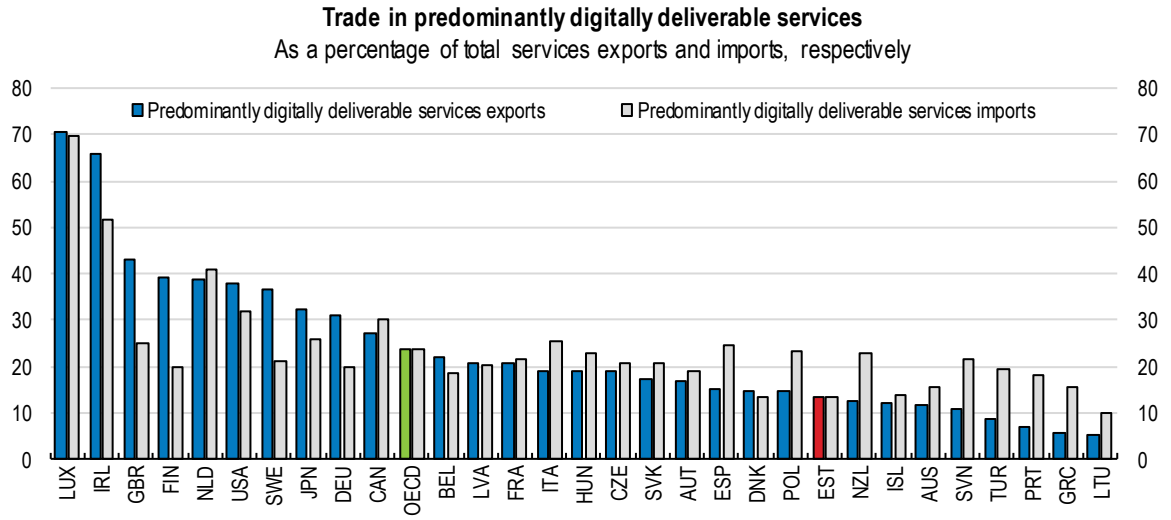


Source: European Commission 2018 PREDICT Dataset.

35. ICT-sector competiveness can be measured also by the extent of digital trade, where Estonia's performance could improve (Figure 15). The low extent of trading in digitally deliverable services is surprising as Estonia has the lowest barriers in OECD to services trade, alongside Norway, Australia and Switzerland (Ferencz, 2019). Telecommunications, computer and information services make up most of Estonia's exports and imports in digitally deliverable services. While financial as well as insurance and pension services are not a competitive edge of other catching-up economies, either, some other countries such as Hungary have been more successful in earning IPR-related revenues from overseas. Low revenues from exporting IPR are related to relatively low patenting activity in general.

Figure 20. Trade in digitally deliverable services is low

Trade in predominantly digitally deliverable services as a percentage of services exports and imports, respectively

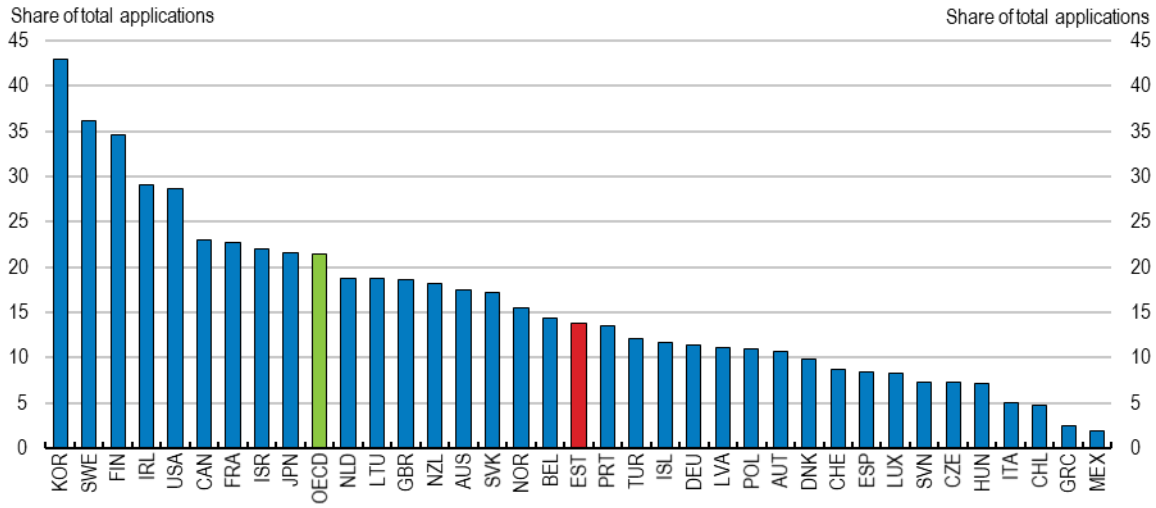


Note: OECD average is the simple average of 29 members not including Chile, Israel, Korea, Norway and Switzerland, for which data were not available. Digitally deliverable services include financial services, insurance and pensions, telecommunications, computer and information, audio-visual services and charges for intellectual property use.
Source: OECD (2019), Measuring the Digital Transformation: A Roadmap for the Future, OECD Publishing, Paris, https://doi.org/10.1787/9789264311992-en.

36. When it comes to measuring innovation performance of the ICT sector, Estonia lags behind the OECD average in the share of ICT-related patents (Figure 16). This gap is related to the very strong output by a few countries including Korea, some Scandinavian countries, Ireland and the United States. Among the Central and Eastern European economies, however, only Lithuania and Slovakia fare better. In general, Estonia fares better in trademarks and industrial design compared to patents. Low patenting activity in the ICT sector in Estonia may be related to the small size of firms in the sector, with most newly created businesses having no employees, while patenting is research- and labour intensive. Planned increases in government spending on research and development are expected to boost innovation economy-wide.

Figure 21. The share of ICT-related patents is low

ICT patent applications as a share of total patent applications to the European Patent Office, 2016



Source: Eurostat.

37. The government's ICT Vision 2020 has set ambitious objectives for the ICT sector: a doubling of the sector's share in GDP between 2013-20, labour productivity in the sector reaching two-thirds of that in Nordic countries and employing 50 000 additional workers with ICT practitioner skills. While this last objective is hard but not impossible to attain, the first two will likely remain a far reach with the recent stalling of the ICT share in value added and with ICT labour productivity below a third of that in Finland. The ICT Development Programme gives a more medium-term perspective, with industry development proposals until 2030. In the coming decade, greater attention needs to be paid to enhance innovation in the sector, which could contribute to raising the sector's productivity and hence also its international competitiveness. In addition, successful home-bred start-ups should be encouraged to interact more with the domestic economy. As discussed below, ICT skills are highly concentrated in the ICT sector in Estonia. Plans to boost the ICT sector are thus welcome, but should not take focus off efforts to leverage the considerable capabilities embedded in the ICT sector to disseminate digital technologies in the business sector. Digitalisation of the business sector would also boost demand for ICT services and competition in the sector.

Making the most out of skills

38. Firms have different abilities to push productivity growth, under similar conditions, with similar technological solutions available, within the same sector, and even with the same owners (Bloom et al., 2019). Humans are at the centre of such differences. Owners, managers and workers come with different backgrounds, incentives and abilities, affecting the firm's ability to innovate and boost performance. The knowledge of what is going on inside firms, driving their different abilities, is still limited (OECD, 2019b). What is known, is that a wide set of skills are essential to support adoption and effective use of digital technologies, and maximise their productivity impact. These skills can be divided into three main categories: specialised skills of ICT professionals, ICT user skills for other workers and other, complementary skills. The latter group includes notably general cognitive skills and managerial and organisational skills, but also other skills, such as social- and interpersonal skills. Skill shortages can reduce the benefits from digitalisation, especially among less-productive firms, as it is more difficult for

them to attract skilled workers than for more productive firms (Sorbe et al., 2019; Grundke et al., 2018; OECD, 2019a, Mosiashvili, 2019).

39. The benefits from boosting skills and utilising existing skills better in Estonian firms are clear. Firms scoring one standard deviation (30%) higher than average on the share of employees using computers for work purposes, are estimated to have 4.6% higher annual productivity growth, and positive spill-overs to other firms are sizeable, notably in manufacturing sectors (Pareliussen and Mosiashvili, 2020).

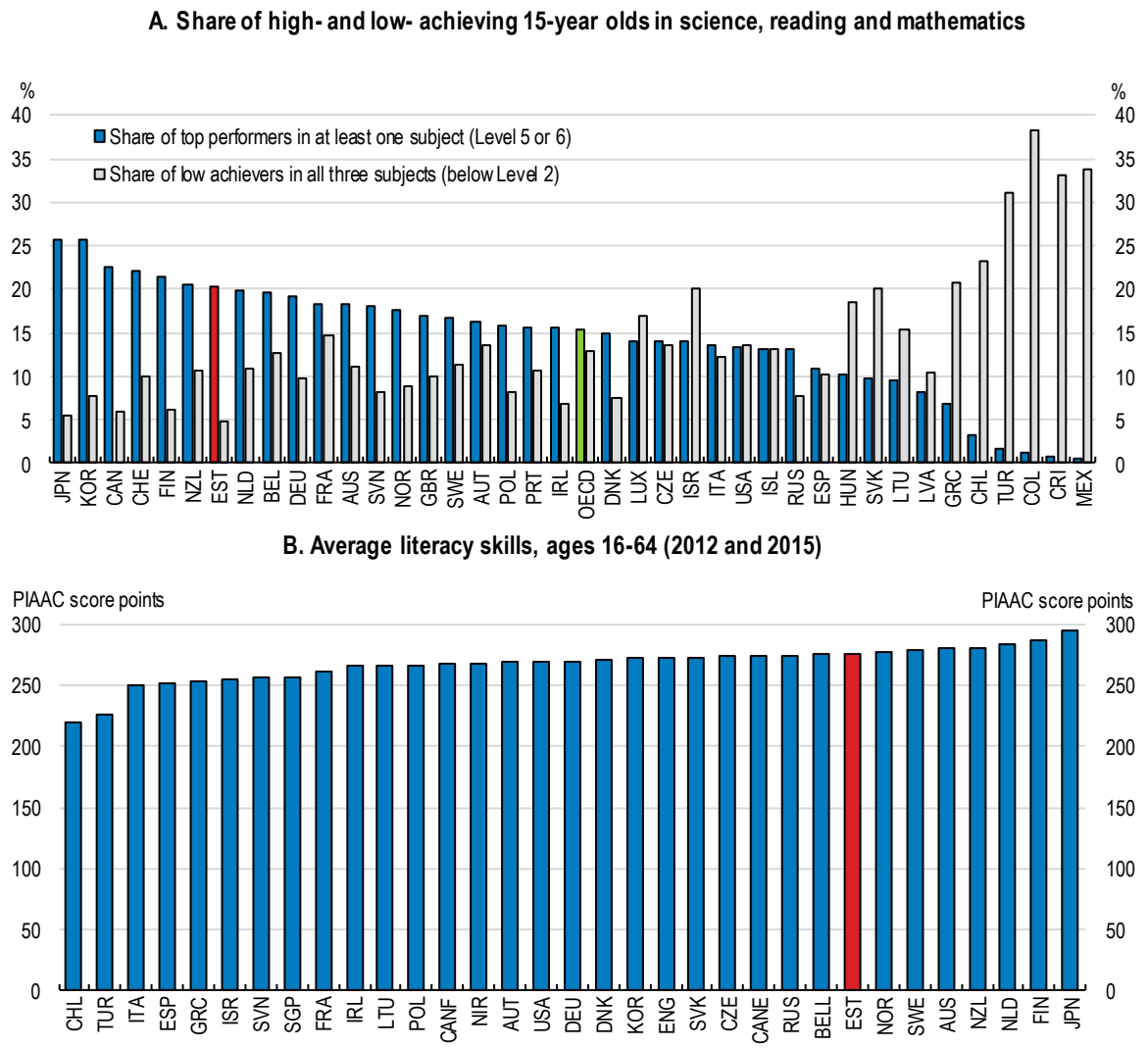
40. Strong basic skills in literacy, numeracy and science is a major strength for the Estonian economy, but successfully implementing digital technologies to increase productivity takes more. Specialised ICT skills and ICT user skills in the workforce are associated with higher up-take of digital technologies in companies. Management skills- and practices are keystones in digital transformation, since managers have a key role in product- and process innovations exploiting complementarities between digital technologies.

Basic skills form the foundation for the effective use of digital tools

41. A minimum level of proficiency in reading and numeracy as measured by the OECD Survey of Adult Skills (PIAAC) serves as a basis for using digital technologies. Higher levels of such cognitive skills enable individuals to perform more diverse and complex digital tasks, necessary to thrive in digital-intensive workplaces, rather than just using the Internet for information and communication. Furthermore, skills in science, literacy and numeracy serves as a foundation to obtain new skills, which can help individuals adapt to a fast-moving digital landscape (OECD, 2019c; OECD, 2019d).

42. Estonian 15-year-olds are among the top performers in the OECD's Programme for International Student Assessment (PISA), ranking second in science, fourth in reading and fourth in mathematics in 2015. The country also has a high share of high achievers and the lowest share of low achievers in the OECD (Figure 22, Panel A). Adult skills are well above the PIAAC average in both literacy and numeracy (Panel B).

Figure 22. Basic skills are high



Note: The second round of the PIAAC Survey (2015) added Chile, Greece, Indonesia, Israel, Lithuania, New Zealand, Singapore, Slovenia and Turkey.
Source: OECD, PISA 2015 Database, Tables I.2.4a, I.2.6, I.2.7, I.4.4a and I.5.4a; OECD Survey of Adult Skills Database (2012 and 2015).

43. Notwithstanding a high overall performance, the education system is under pressure to adapt to demographic headwinds, with a shrinking of the prime working-age population going forward. Reducing the rate of early leavers, which at 10.8% stands above the EU average (European Commission, 2019b) is a challenge. The share of young adults not in employment, education or training (NEETs), is at 12%, approximately at the OECD (and EU) average (OECD, 2018a).

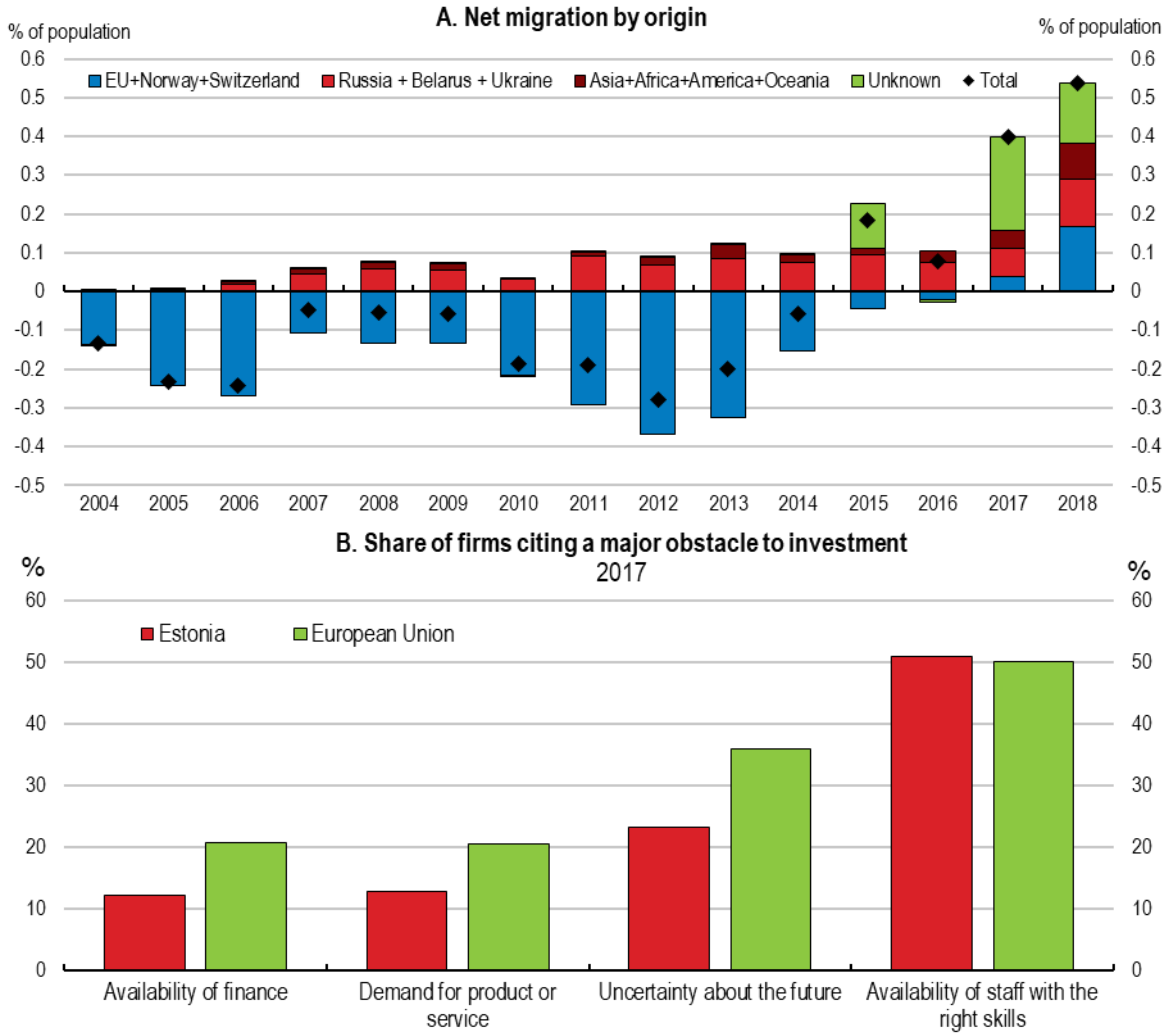
44. Tertiary educational attainment increased from 34% in 2007 to 43% in 2017, which is approximately at the OECD average (44% in 2017). However, there is a significant gender gap, with 53% of women having a degree, compared to 34% of men. The proportion of graduates in science, technology, engineering and mathematics (STEM) is increasing, but their share of the young population (aged 25-34) is only 12.2%, lower than the EU average of 15.5%. Estonia's forecasting system for future labour and skills needs OSKA is useful in addressing skills needs and shortages. It analyses and forecasts sectoral

needs for labour and skills with a combination of qualitative and quantitative research methods, and reviews professional qualifications across all levels of education.

45. Adult education and training (AET) is important to address changing skill needs against the background of higher life expectancy and rapid structural change. Participation in AET increased considerably from 10% in 2008 to 19% in 2018 (European Commission, 2019b), which places its target to reach 20% in 2020 within reach. However, as pointed out in the 2017 OECD Economic Survey of Estonia and further discussed below, businesses are little involved in the provision of both adult education and vocational education and training.

46. Access to the right skills, digital and complementary, is often a prerequisite to invest in productivity-enhancing technologies. There is scope to enhance the skill supply from non-EU immigration to fill skills shortages. Net migration was negative until 2015, and is still modest, while employers cite the lack of staff with the right skills as their biggest obstacle to investment (Figure 23). Skills shortages in Estonia are generally not filled by free labour movement through immigration, as the income level is considerably lower than in nearby EU countries, notably Finland. Non-EU work immigration to Estonia is relatively restricted, despite strong demand from businesses and potential immigrants of various backgrounds and skills, notably from Ukraine and Russia. An annual quota for long-term residence- and work permits of 0.01% of the population, or 1315 people in 2019, was oversubscribed already in December 2018. Exceptions do exist, however. Those receiving at least double the national average gross salary are exempt, and there are general exemptions for ICT specialists, recruitments to start-ups, citizens of the United States and Japan, as well as international students.

Figure 23. Restricted work immigration may hold back digital adoption

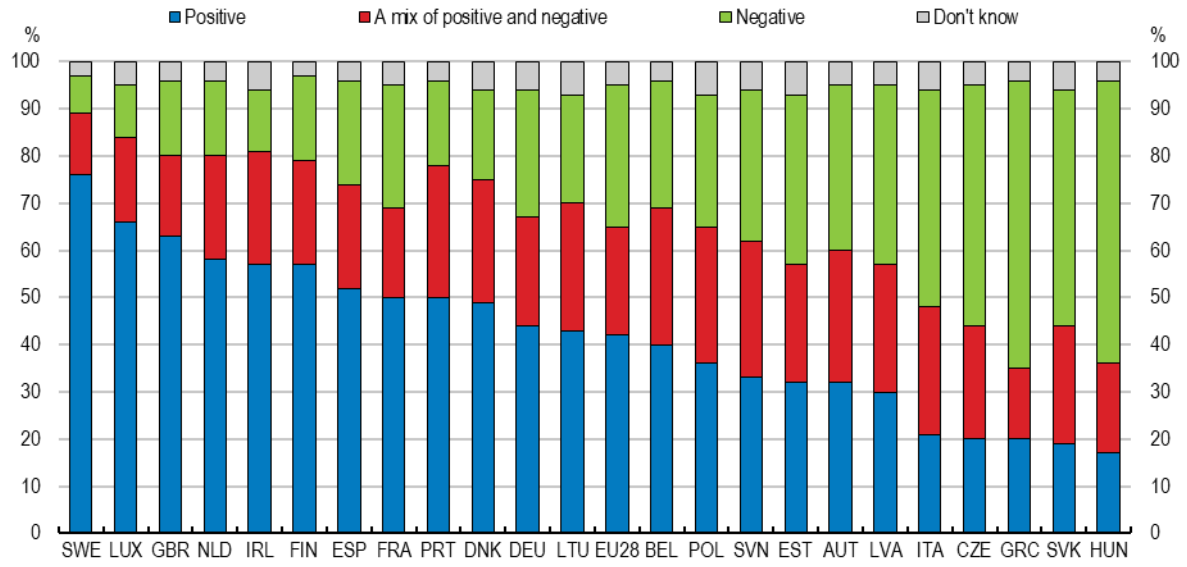


Note: Firm responses to the question: "Thinking about your investment activities in your country, to what extent is each of the following an obstacle? Is it a major obstacle, a minor obstacle or not at all an obstacle?"
Source: Statistics Estonia; European Investment Bank: EIBIS, the EIB Investment Survey.

47. From a political economy point of view, restrictions reflect relatively negative attitudes to immigration (Figure 24). Looking at the economic side, however, Estonia would likely benefit from loosening restrictions on work immigration. It could help alleviate demographic headwinds expected to shrink Estonia's working-age population (15-64 year-olds) by close to 8% and increase the dependency ratio from 57% to 66% from 2019 to 2040 (Statistics Estonia, 2019). Immigrants tend to be young, economically active and mobile, they arrive with skills, often complementary to those of the receiving country, contributing to human capital and technological progress (OECD, 2014; Boubetane and Dumont, 2013). The blanket exemption for ICT specialists is notably helpful in the context of digitalisation, but restrictions on complementary skills may still limit digital adoption, notably outside of the ICT sector. 12-month work visa ("D-visa") are available upon application without quantitative limitations (Work in Estonia, 2019) and provide some welcome flexibility. However, their usefulness to employers are limited by costs incurred, notably time costs of training new arrivals, but also associated management costs. The threshold of two times the average wage may still be too high to attract highly qualified workers, notably young workers in entry-level positions. A more flexible approach, taking various measures of skills into account, or lowering the wage threshold should be considered.

Figure 24. Many perceive the impact of immigrants in society as negative

Perceptions regarding the impact of immigration on society (2017)

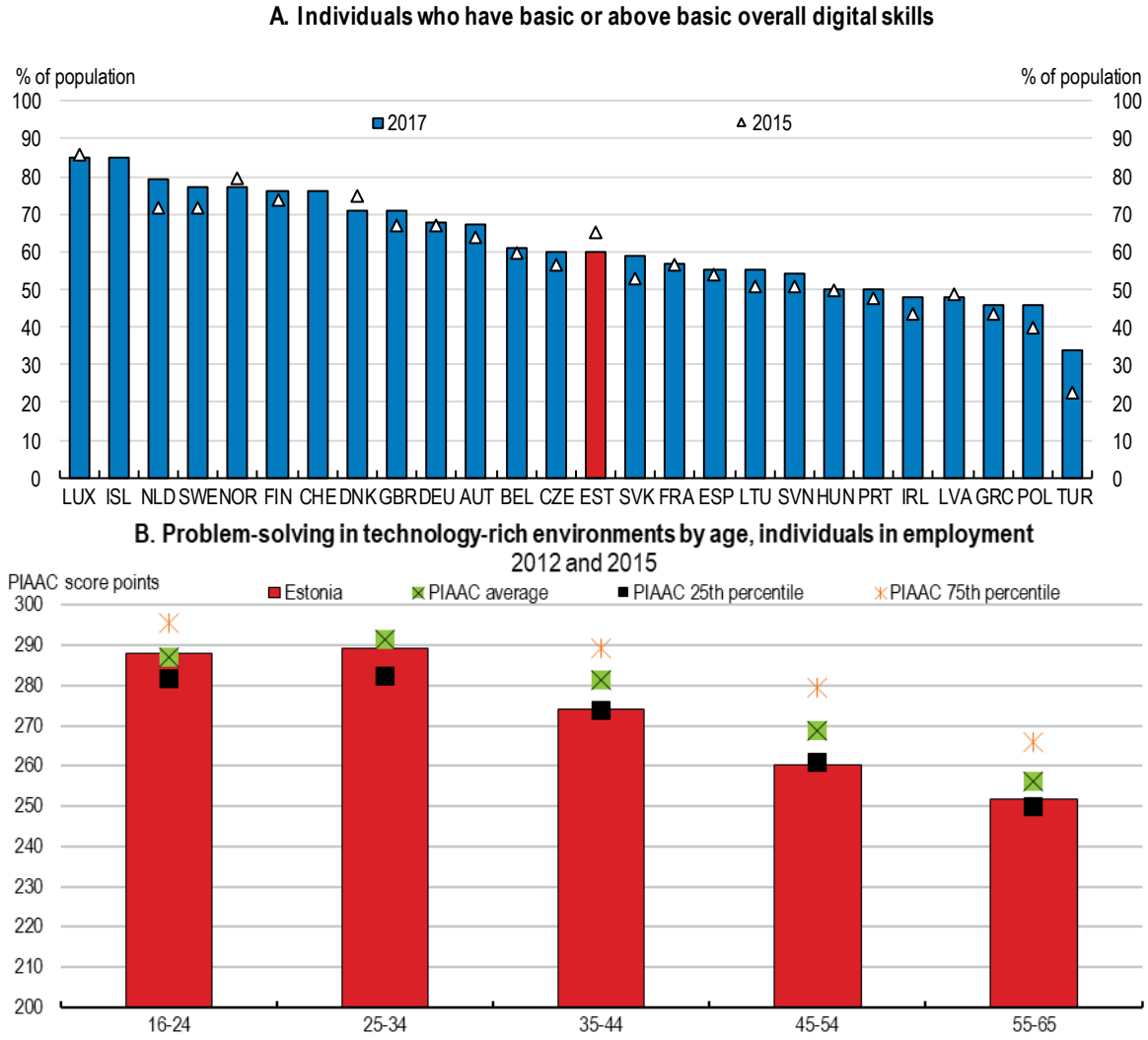


Source: European Commission, 2018a.

Digital user skills could be improved

48. Higher digital user skills are associated with higher productivity at the EU regional level, and the share of workers using computers for work purposes is associated with a sizeable productivity premium at the firm level and spill-over effects, translating into sectoral productivity gains (Männasoo et al., 2020; Pareliussen and Mosiashvili, 2020). The share of individuals who use various digital tools is above the EU average and fellow Baltics Latvia and Lithuania, but well behind the best performing countries, Finland and the other Nordics (Figure 25, Panel A; European Commission, 2018b). However, the PIAAC Survey, which measures digital problem-solving skills more directly, shows that Estonia lags well behind the average country. Many adults (about 25%) lacked basic computer skills at the time of the survey, a share three times higher than in top performing countries. Younger generations of adults are more digitally proficient than older ones both in absolute terms and relative to peer countries, although performance also in these age groups is only around the PIAAC average (Panel B). Boosting digital skills calls for concerted efforts in schools, universities and adult education and training.

Figure 25. Adult digital skills are below average in international comparison



Note: Panel A: % of individuals aged 16-74. The basic or above basic overall digital skills represent the two highest levels of the overall digital skills indicator, which is a composite indicator based on selected activities performed by individuals aged 16-74 on the internet in the four specific areas of information, communication, problem solving, content creation. Panel B: The second round of the PIAAC Survey (2015) added Chile, Greece, Indonesia, Israel, Lithuania, New Zealand, Singapore, Slovenia and Turkey.
Source: OECD Survey of Adult skills (2012 and 2015).

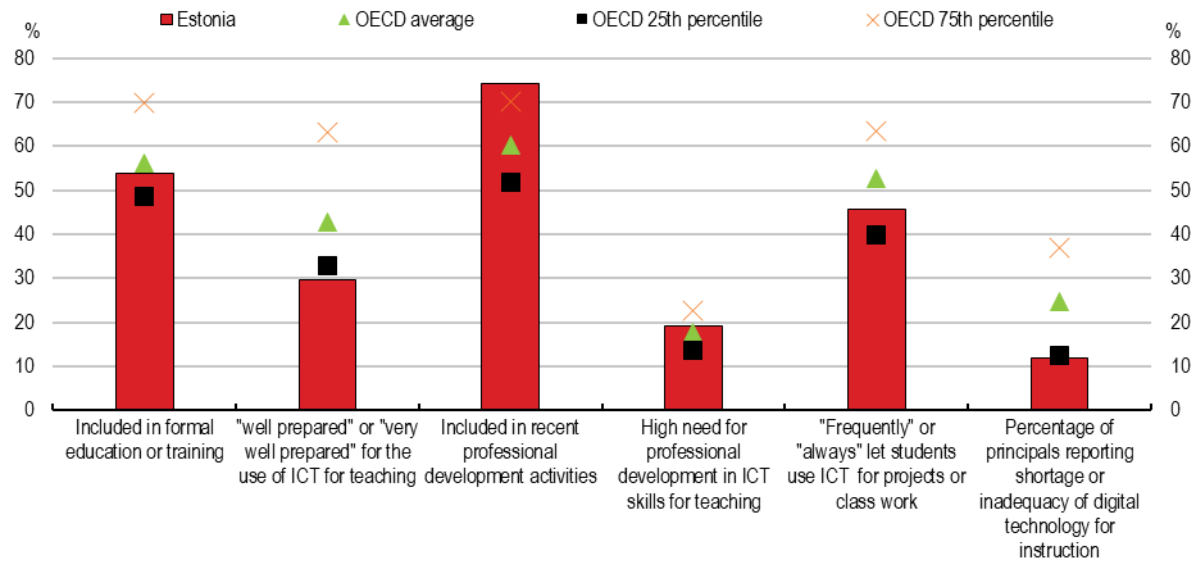
49. Digital competence is one of eight compulsory competences defined in the national curriculum in compulsory school. Estonian schools have high autonomy to implement curricula and learning outcomes (OECD, 2016a). As outlined above, this model serves Estonian children well, but in lack of coordination there is a risk that pupils in some schools do not get the opportunity to attain an acceptable level of relevant ICT skills. In response to this challenge, the government has developed additional guidelines, trained teachers and distributed guidelines and learning materials. National tests indicate that 83% of 9th grade students fulfilled criteria for basic ICT skills set in Estonia's Lifelong Learning Strategy 2020.

50. Teachers' digital skills and their preparedness to teach digital skills should be strengthened by intensifying and increasing the quality of their professional development in the subject. Estonian teachers' digital problem-solving skills rank the same as the total population in comparison to other PIAAC countries. Nonetheless, teachers do not feel sufficiently prepared to teach digital skills and use digital tools, even

though a majority has received recent training in the use of ICT for teaching. The access to and quality of digital devices, environments, software and digital study materials is adequate in most schools (Figure 26). The support programme ProgeTiger has played an important role in integrating technology education into the curriculum, offering teachers educational resources and training opportunities and co-financing equipment and software in preschool, primary and vocational education. The Information Technology Foundation for Education (HITSA) runs the programme in partnership with the Ministry of Education and Research, financed by the European Social Fund.

Figure 26. Teachers' preparedness to use ICT for teaching could improve

Percentage of teachers reporting about the "use of ICT for teaching"



Source: OECD, TALIS 2018 Database, Table I.4.13, Table I.4.13, Table I.5.18, Table I.5.21, Table I.2.1 and Table I.3.63.

51. Estonian businesses are little involved in the provision of both upper secondary vocational education and adult education and training. On the other hand, there is a clear link between productivity growth and employees participating in ICT training (Pareliussen and Mosiashvili, 2020). Furthermore, the successful digitalisation of processes will in many cases depend on providing complementary training to employees.

52. A lack of size is often cited as an obstacle to investing in digital technologies and skills. More than 90% of Estonian companies had less than 10 employees in 2016, and 0.24% of companies have 250 or more employees. Indeed, small companies provide less training to their employees than larger ones in general, and in the field of ICT. However, this challenge is not unique to Estonia, and the share of small companies is not a function of the size of the population. The EU average country has 94% companies with less than 10 employees and 0.19% large companies. Both small countries such as neighbouring Latvia and Lithuania and large countries, such as France and Italy have higher shares of small companies and lower shares of large companies than Estonia (Eurostat, 2019). However, Estonian companies within each firm-size group are among the least inclined to provide ICT training to their employees. They do slightly better than companies in the other Baltics, but lag significantly behind the Nordics and other high performers (Figure 27). There may be scope to better incentivise companies to train their staff, notably smaller companies, as current grants and incentives are mostly directed to medium- and large-sized businesses, and several OECD countries have programmes to this end (Box 4; European Commission, 2019b).

Box 4. Examples of programmes to develop companies' training of personnel

Authorities develop companies' capacity to provide relevant training in various ways, but such programmes typically involve one or more of the three following elements:

- Targeted coaching to help companies identify their skill needs and develop an appropriate training offer.
- Providing financial incentives for SMEs, along with advice and guidance.
- Facilitating networks of firms within and across sectors for peer learning.

Finland provides financial incentives along with capacity building to identify companies' training needs and deliver training through the "Joint Purchase Training" (Yhteishankintakoulutus) programme, offered by the Public Employment Service (PES). The programme offers different types of training ranging from 10 days to two years. Training responds to different needs, for example re-training of employees affected by technological change or redundancies, or training new hires in specific skill-sets not available among job-seekers.

The Korean Subsidies for Learning Organisations helps build the capacity of SMEs to develop their staff through various subsidies. Support is available to hire external consultants to analyse the company's training needs, to build the capacity of the CEO, managers and staff responsible for learning activities, and facilitate the systematic integration of learning in the organisation. In addition, subsidies are available for peer-learning activities.

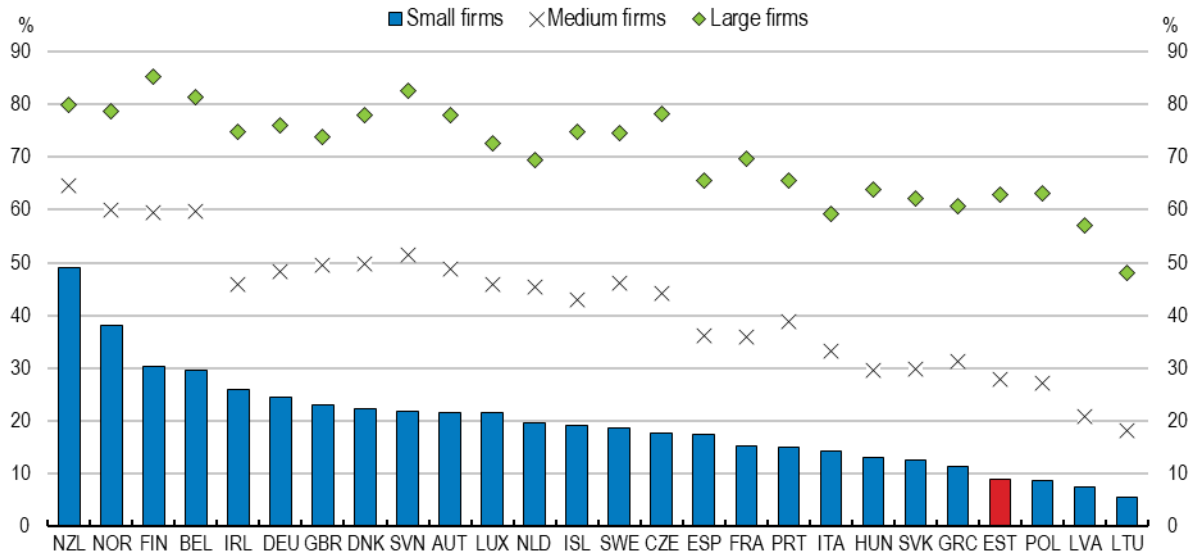
Social partners can play a key role in programmes to help build employers' capacity to train their staff for the future. In Germany, the initiative "Securing the skilled labour base: vocational education and training (VET) and gender equality" (Fachkräfte sichern: weiterbilden und Gleichstellung fördern) funds 93 projects implemented by social partners to increase adult learning participation and gender equality at work. Funding is provided for five types of activities: i) building staff development and training structures, particularly for skill upgrading; ii) creating interlinked VET structures for SMEs; iii) initiating networks and peer learning across branches of industry; iv) strengthening the ability of business stakeholders to promote equality of opportunity; v) developing work time models and career pathways adapted to phases in a worker's life. As an example, one project helps utility companies in the three German cities of Coburg, Kronach and Lichtenfels to implement staff development and training structures, including coaching and training for key staff on analysing their skill and training needs and working with partners.

Source: OECD (2019), Getting Skills Right: Engaging low-skilled adults in learning, (www.oecd.org/employment/emp/ adult-learning-systems-2019.pdf).

53. Estonia pursues a number of policies to cover parts of the training costs for people already in employment. Together with Estonian IT companies, the government has launched the adult education project Choose IT, further described below. Cooperation and dialogue between the government and employers' and labour unions is likely part of the reason why this scheme has already had some success. The government and manufacturing industry has also recently launched a digital skills training project called DigiABC for unskilled workers, targeting the workers through their workplaces. These programmes may serve as inspiration on how to involve businesses more in adult education and training in cooperation with employers and labour unions.

Figure 27. Small firms provide less ICT training than larger ones

Percentage of businesses providing ICT training to their employees by size class (2015)



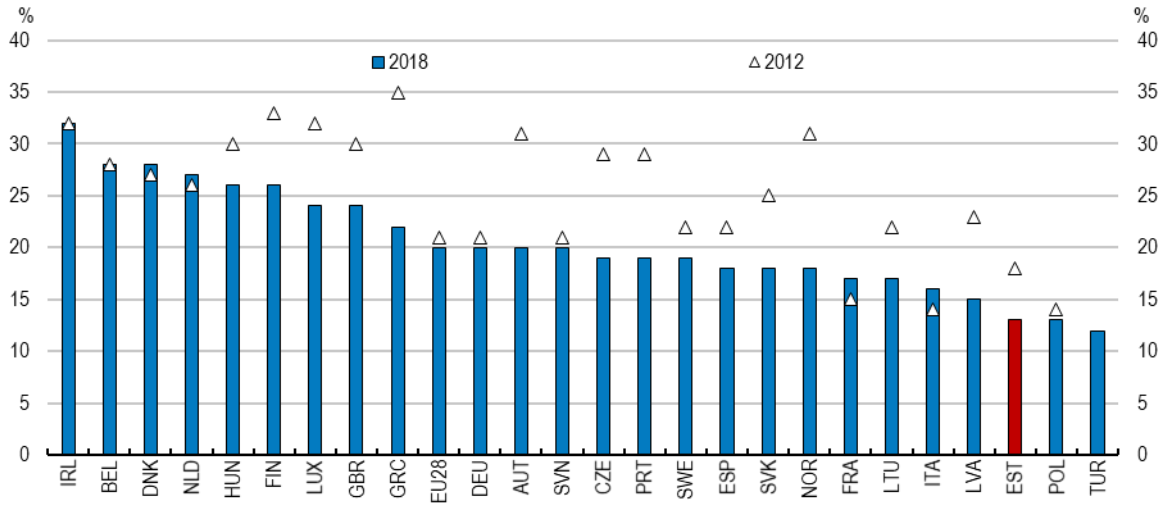
Note: Data refer to businesses with 10 or more employees that provided any type of training to develop the ICT related skills of their employees within the last 12 months. Data for New Zealand refer to 2016 and Iceland to 2014. Data for medium-sized firms in Portugal refer to 2017. Businesses with 10-49, 50-249 and 250 or more employees are defined as small, medium and large, respectively.
Source: OECD (2017) ICT Access and Usage by Businesses Database (http://dx.doi.org/10.1787/58897a61-en).

Specialised ICT skills are concentrated in a small number of companies

54. Estonia has a successful cluster of ICT companies, helped to grow and deepen by the country's long-standing commitment to e-government. ICT specialists constituted 5.3% of total employment in 2016, well above the EU average of 3.7%. However, ICT specialist employment is highly concentrated in relatively few companies (Figure 28), underlining Estonia's challenges in leveraging its sizeable ICT specialist workforce and significant know-how in the ICT sector to boost productivity-enhancing digital adoption in the non-ICT business sectors.

Figure 28. Employment of specialised ICT personnel is highly concentrated

Share of enterprises that employ ICT specialists

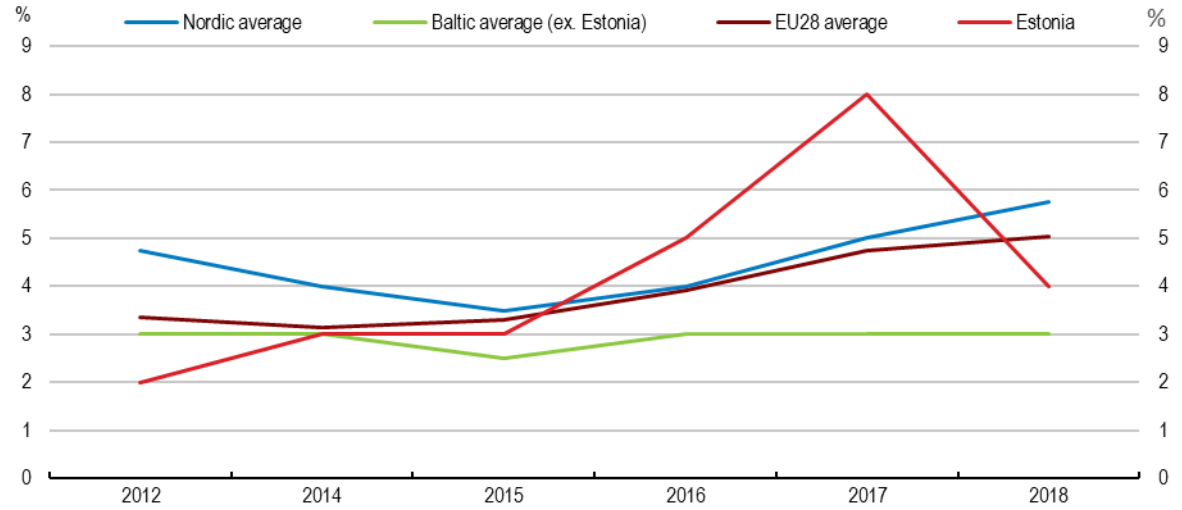


Source: Eurostat Digital economy and society database (accessed 25 July 2019).

55. Shortages of ICT specialists have been found to reduce firm-level productivity in Estonia (Mosiashvili, 2019). Recent shortages of specialised ICT personnel were considerable, but seem to be abating (Figure 29) as the supply of ICT personnel is increasing. The share of tertiary education graduates specialised in ICT increased from 5.3% in 2013 to 7.4% in 2017, more than double the EU average (3.6% in 2017), considerably higher than Latvia (2.7%), Lithuania (5.0%) and somewhat higher than Finland (6.3%). The expansion of ICT graduates from upper secondary vocational education has been even stronger, increasing from 4.8% in 2013 to 13.6% in 2017, one of the highest shares in the EU, and well above the levels in Latvia (7.0%), Lithuania (2.0%) and Finland (3.6%). Supply of ICT professionals is further boosted by the Choose IT programme, funded by the European Social Fund and launched in 2017, aiming to let 500 postgraduates attend a six-month software developer programme resulting in a bachelor degree in programming by the end of 2020. This approach holds promise, as it equips people holding valuable prior experience and knowledge with digital knowhow. Such multidisciplinary skills may be valuable both to the ICT sector and traditional sectors, and may help build better understanding and better links between the two.

Figure 29. Shortages of ICT specialists are easing

Share of enterprises with hard-to-fill vacancies for jobs requiring ICT specialist skills



Source: Eurostat digital economy and society database (accessed 26 June 2019).

56. As in most OECD countries, an overwhelming majority (83%) of people employed as ICT specialists are men. Young men (16-24 year-olds) are more likely than young women to have programming skills, in Estonia and elsewhere (OECD, 2019d). This gender imbalance reflects educational choices. Only 11% of upper secondary vocational ICT graduates, and 28% of tertiary education ICT graduates were women in 2017. EU averages were 11% and 19%, respectively (Eurostat, 2019b). At the same time, women tend to use ICT more intensively at work (OECD, 2019d). In order to ensure a more diverse pool of talent in specialised ICT positions, and to counteract gender divides in ICT skills, consorted efforts should be carried out to remove gender biases in how ICT is perceived and taught, to increase girls' interest in ICT from a young age. Providing high-quality ICT education with uniform quality from a young age, with content designed to appeal equally to girls' and boys' interests across Estonia's compulsory schools is important in this respect. Furthermore, the voluntary ICT hobby activities currently organised by 68% of Estonian schools should actively promote a range of activities equally appealing to girls as to boys. Participation in these hobby activities is often stated as a main motivation for choosing an education within ICT later in life.

Management skills and high-performing work practices

57. The evidence of the importance of management to productivity has grown since Bloom and Van Reenen (2007) started measuring management practices. Higher managerial quality improves firm and aggregate productivity. The benefits of superior management practices on productivity are largely realised through within-firm effects, such as the use of high-performing work practices and organisational restructuring to promote more efficient technological adoption, as opposed to higher allocative efficiency. Managers are responsible for assigning human capital to its best use, and to contribute to up-skilling and re-skilling employees to maximise complementarities between digital technologies and skills (OECD, 2019a; Andrews et al., 2018; Pellegrino and Zingales, 2017; Bloom et al., 2019; 2012c and d).

58. Good management- and organisational skills are keystones in digital transformation, since reaping the full productivity potential of technological change requires product- and process innovations, getting the most out of complementary skills and complementary technologies, for example between front- and back-office management software (OECD, 2019a; Andrews et al., 2018; Pellegrino and Zingales, 2017;

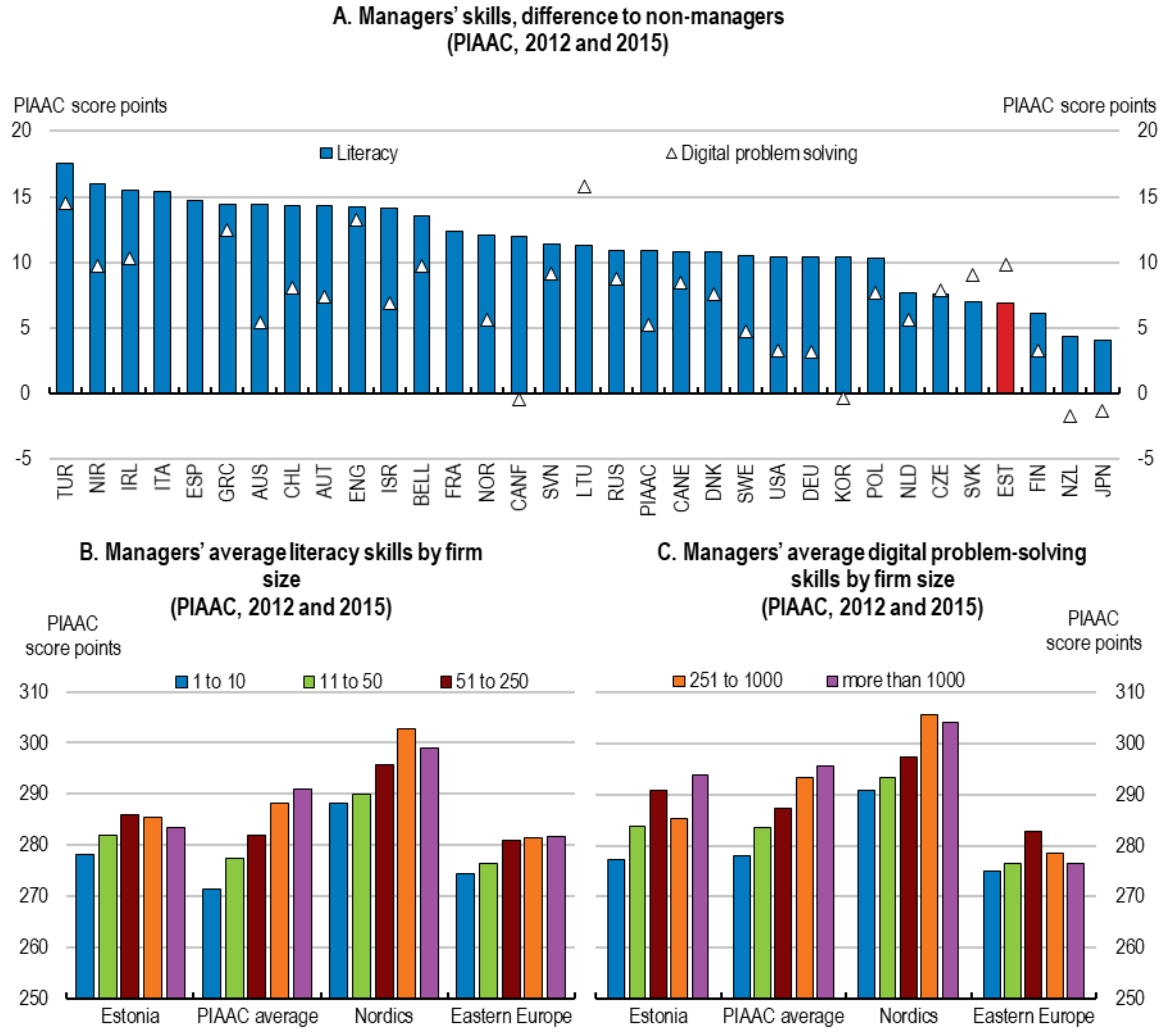
Bloom et al., 2012). Such innovations range from using digital tools to incremental optimisation of current practices to re-defining a company's purpose and business model.

59. A good manager needs a wide range of skills, and a key question to ask is whether those with the highest skills choose to- and are selected to become managers. Language- and processing skills, as measured by the PIAAC survey, where the respondent needs to read a text, understand it and process it to answer one or more questions is a useful indicator of managers' capabilities. Literacy skills are closely correlated with numeracy skills and digital problem solving skills and is associated with flexibility to learn new tasks. Contrasting high literacy skills in the Estonian population, which ranks eight compared to the other countries and regions participating in PIAAC, Estonian managers' skills are around the OECD median. Moreover, the skill level of managers is on average only slightly above the average skill level of non-managers (Figure 30, Panel A).

60. Higher quality of management can improve productivity within firms, but from the perspective of the economy as a whole, these gains will be maximised when the most effective managers command a larger share of the economy's resources (Adalet McGovan and Andrews, 2015 and 2017). This is the case on average across OECD countries, with larger firms tending to have better managers than smaller firms. To some extent, this is also the case in Estonia, where firms with more than 50 employees attract the highest-skilled managers. However, skills of managers in the largest Estonian firms are no higher than in medium-sized ones (Figure 30, Panel B). There are multiple possible reason for this apparent deviation from efficient allocation of managers (further discussed later in the paper), including lack of competition; cumbersome regulations affecting product and labour markets, and; an inefficient ownership structure (for example, managerial quality is highest in multinational enterprises and lowest in family managed firms).

61. As part of a diverse skill-set, and notably in the adoption of digital technologies, managers need digital skills. Digital problem solving skills in the population, as measured by PIAAC, places Estonia in the bottom quartile of participating countries and regions. Managers are however considerably more digitally proficient than Estonians without management responsibilities (Figure 30, Panel A), and the most digitally proficient managers are found in the biggest companies (Panel C).

Figure 30. Managers' skills could be higher and utilised more efficiently

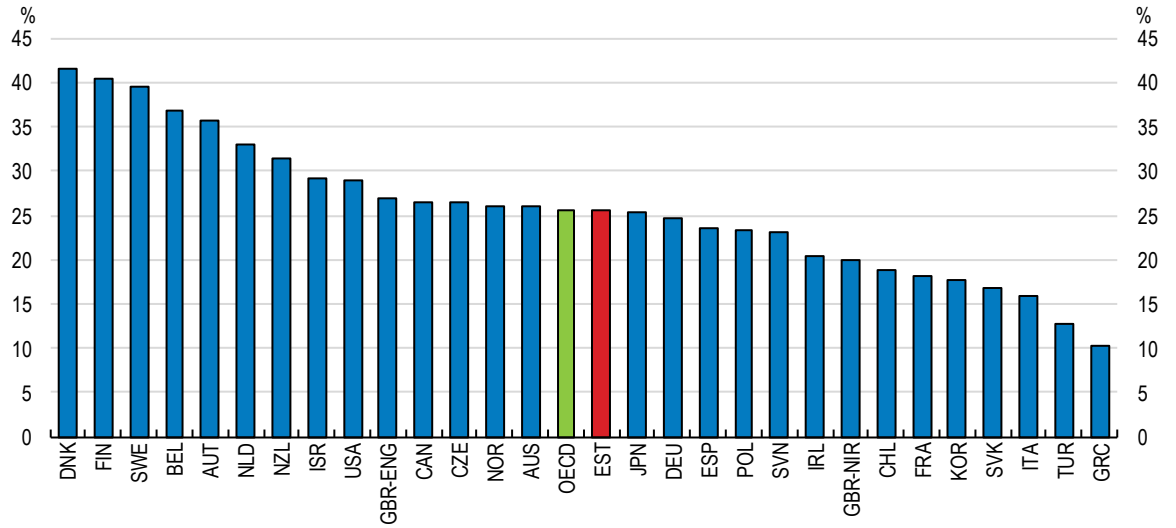


Note: Managers are defined as personnel managing at least one colleague. The second round of the PIAAC Survey (2015) added Chile, Greece, Indonesia, Israel, Lithuania, New Zealand, Singapore, Slovenia and Turkey. The skill difference between managers and non-managers presented in Panel A is the coefficient of a dummy variable taking the value one for managers in an OLS regression controlling for sector composition.
Source: Author's calculations based on OECD Survey of adult skills (2012 and 2015).

62. An alternative way of investigating the quality of management is through the lens of high-performing work practices (HPWP). HPWPs include both aspects of work organisation, such as teamwork, autonomy, task discretion, mentoring, job rotation, applying new learning, and management practices such as employee participation, incentive pay, training practices and flexibility in working hours. Studies have shown strong links between HPWPs and productivity performance. There is a strong relationship between HPWPs and individuals' skill use at work. Workers who benefit from any degree of HPWPs make greater use of numeracy, writing, reading, ICT and problem-solving skills than those who do not, and skill use increases with the intensity of HPWP use (OECD, 2016b). The use of HPWPs in Estonia is around the PIAAC average and lags well behind best performers (Figure 31).

Figure 31. The use of high-performing work practices is around average

Percentage of jobs with High-Performance Work Practices (2012 and 2015)



Note: Data collected in 2012, except for Chile, Greece, Indonesia, Israel, Lithuania, New Zealand, Singapore, Slovenia and Turkey, for which data were collected in 2015 in the second round of the PIAAC Survey. BELL refers to Belgium (Flanders), GBR-ENG to United Kingdom (England), and GBR-NIR to United Kingdom (Northern Ireland).
Source: OECD Employment Outlook 2016 fig 2.10A, calculations based on the OECD Survey of Adult Skills (PIAAC) 2012 and 2015,

63. The government can play a role in disseminating high-performing organisational- and management practices. The government can adopt such practices in public administrations and government-owned enterprises, with spill-overs to the private sector over time. Lean regulations in product- and labour markets is a strength in Estonia, encouraging firms to improve their management practices and contributing to the exit or restructuring of poorly managed firms. Plans to reform a relatively strict insolvency regime are welcome. Estonia's openness to trade and foreign investment can also be beneficial for management practices since multinationals are, on average, better managed than other firms (OECD, 2019a). Finally, family-owned firms run by family members are in general badly managed compared with similar family-owned firms run by external CEOs (Bloom et al., 2012a). Managers of Estonian family-owned companies tend to value the satisfaction of family members and continuity of family business traditions over profits and expansion (Kirsipuu, 2013), indicating that family ownership may have negative productivity effects in Estonia. Avoiding tax rules overly favourable to family transmission of firms may help. There is no inheritance tax in Estonia, but the gains from the transfer of property received as a gift or inheritance are taxed as income.

64. Several OECD countries, including Australia, the Netherlands, New Zealand and Sweden have implemented programmes to improve managerial and organisational performance of firms. For example, the Finnish Workplace Development Programme (TYKE from 1996 to 2003, TYKES from 2004 to 2010, thereafter Liideri) aimed to disseminate new work, organisational and management practices, models and tools, and to develop a "learning organisation" culture to counter sluggish productivity growth in many traditional industries. Initially it focused on individual enterprises, but networks played an increasing role and there was a strong emphasis on disseminating good practice and mutual learning. Qualitative evaluations suggest that the programmes did promote workplace innovation and productivity. Coaching, promoting best practices and disseminating these through the creation of networks of firms are also common features of other countries' programmes (OECD, 2019e).

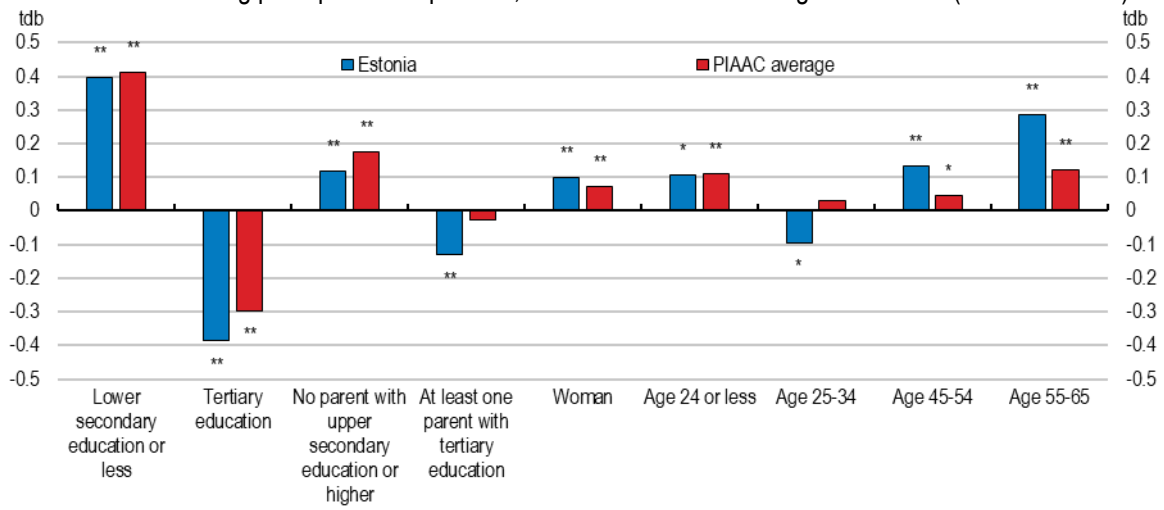
Automation and changing skill demands pose challenges

65. The digital transformation implies vast shifts in skill demand (Grundke et al., 2018; OECD, 2019e). The demand for skills that are easier to substitute with digital technologies has already been declining, while the demand for skills that are complementary to technologies has been increasing (OECD, 2019a, Männasoo et al., 2020). Automation started with manual routine tasks, typically in manufacturing activities, but is increasingly affecting cognitive routine tasks that are typical of service sectors. Further technological advances, for example in speech and image recognition boosted by artificial intelligence, will increase the range of tasks which can be automated, also in relatively high-skilled occupations. Certain jobs will disappear, but an overall decline in labour demand is unlikely as new tasks and new types of jobs emerge (Gregory et al., 2019). Nedelkoska and Quintini (2018) assess that 14% of jobs in OECD countries are highly automatable, and that another 32% may undergo significant changes due to automation. Estonia is not shielded against these developments, with 12% of jobs highly automatable, and an additional 31% at risk of significant change. This offers the potential to enhance productivity but will also involve transition costs, as structural shifts in labour demand will not be distributed evenly across the population (OECD, 2019a).

66. Those individuals most vulnerable to automation may also be those least prepared to adapt. In Estonia, as in other OECD countries, people with low education and skills, those from less favourable social backgrounds, women and older workers are more likely to work in jobs with less exposure to tasks that humans typically perform better than machines, such as using skill or accuracy with hands and fingers, instructing and advising people, negotiating, persuading and selling. Estonia differs notably from other countries in a steep age profile in the vulnerability to automation, which may in part reflect that the education older generations attained under communist rule has lost relevance more quickly than in the average country (Figure 32).

Figure 32. Vulnerability to automation depends on education, social background, gender and age

Exposure to tasks involving perception manipulation, creative- and social intelligence at work (2012 and 2015)



Note: The bars in the figure represent the regression coefficients from an OLS regression of demographic variables on an index of the vulnerability to automation. The index, ranging from 0-5, was constructed as a simple average of ten variables identified as "Engineering bottlenecks" in Nedelkoska and Quentini (2018), measuring the intensity of perception manipulation, creative- and social intelligence at work. The reference individual is a man aged 35-44 with upper secondary education and at least one parent with upper secondary education. The first round of the PIAAC Survey (2012) included Australia, Austria, Belgium (Flanders), Canada, the Czech Republic, Denmark, Estonia, Finland, France, Germany, Ireland, Italy, Japan, Korea, the Netherlands, Norway, Poland, the Russian Federation, the Slovak Republic, Spain, Sweden, the United Kingdom (England and Northern Ireland) and the United States. The second round (2015) added Chile, Greece, Indonesia, Israel, Lithuania, New Zealand, Singapore, Slovenia and Turkey. Coefficients marked with ** and * are statistically significant at the 99% and 95% level, respectively.
Source: Author's calculations based on the OECD Survey of Adult Skills, 2012 and 2015.

67. Ensuring that the labour force has the right skills for a changing environment, and reducing the personal costs for displaced workers to make the transition more equitable is key for Estonia going forward. However, both active and passive support to the unemployed in Estonia are relatively weak. Only 47% of the registered unemployed are covered by unemployment benefits, notably because of stringent eligibility criteria. The benefit amount is also low, in many cases below the subsistence minimum level (Praxis, 2019a). Those not covered can receive social assistance and are eligible for health insurance, which is generally conditional on employment.

68. Targeting resources towards up-skilling and re-skilling the unemployed, notably those unemployed with low skills or whose skills have become obsolete, is key to meet changing skill demands and reduce the social cost of the digital transformation. The low-skilled are more likely to do jobs with a high routine content, and they are typically less autonomous and able to adapt the task content of their jobs to automation. They are thus more likely to become unemployed, and they remain unemployed for longer on average. The Work ability reform, moving disability benefit claimants' from passive to active benefits based on a re-assessment of their work ability, is expected to increase unemployment numbers going forward. The focus of ALMPs has shifted towards building basic digital skills and Estonian language courses to Russian-speaking Estonians. Such training is also increasingly made available to individuals at risk of unemployment, for example in traditional industries in Estonia's North-East. Even tough spending on ALMPs has increased over the past few years, it is still low compared to other OECD countries, and a further effort to ramp up training activities for the unemployed and those in risk of unemployment is warranted. Improving unemployment insurance coverage might also help, notably to the extent it gives the unemployed with up-skilling needs better access to and stronger incentives to participate in training (OECD, 2017b).

69. The development of "gig economy" platforms, offers increased flexibility for workers and firms, and can provide valuable opportunities to displaced workers. However, workers in non-standard forms of employment have more difficulties accessing training compared to standard employees, and the emergence of new forms of work poses a challenge to regulations largely designed for full-time, permanent employees working for a single employer. Furthermore, the balance of power between workers and their employers can be skewed in favour of the employer or platform. Clearly defining and enforcing the employment status of workers, notably the distinction between the self-employed and employees, and minimise opportunities and incentives for the misclassification of workers are essential. Furthermore, rights and protections should be extended to workers where there is genuine ambiguity about their employment status so that these workers in the grey zone can benefit, at least partially, from fair pay, working time regulations, occupational health and safety, anti-discrimination legislation, as well as some form of employment protection (OECD, 2019a; OECD, 2019e).

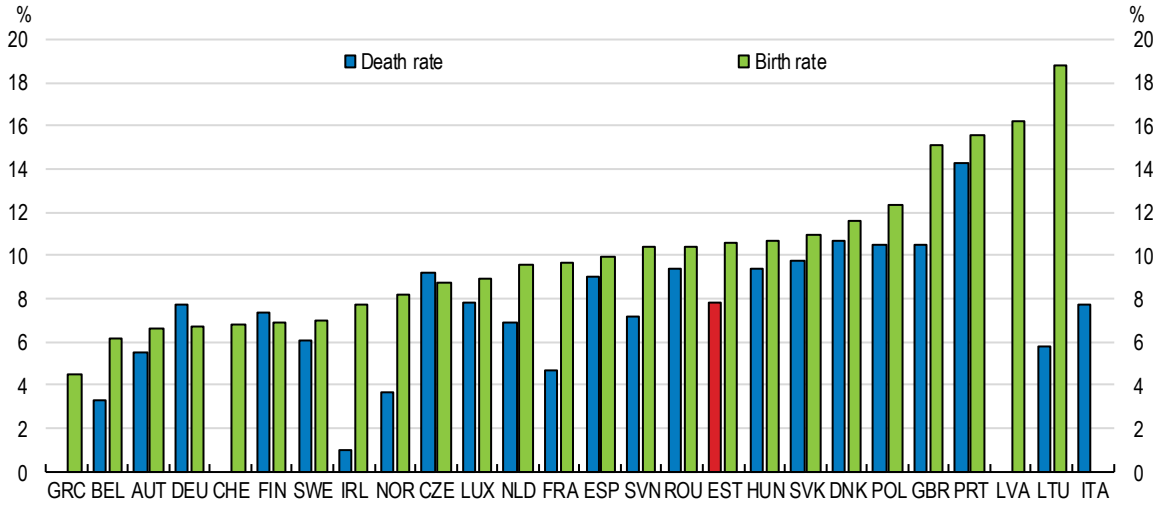
Boosting digital dissemination in a market-friendly environment

70. The productivity slowdown in Estonia, as in other OECD countries, is connected to and increasing divergence between the best-performing firms ("the productivity frontier"), which have seen productivity continue to grow at least as fast as in earlier periods, and the rest (Pareliussen and Mosiashvili, 2020). This result is linked to declining business dynamism, holding back the reallocation of resources towards the most productive companies and tasks. A business-friendly environment with lean regulations and access to markets, skills and capital boosts business dynamism, increases the pace of digitalisation and productivity growth.

71. Regulations are in general highly market-friendly in Estonia, but business dynamics are nonetheless just around the average, with rates of firm creation above the OECD median and destruction around the median (Figure 33). However, birth rates lag well behind neighbouring Latvia and Lithuania. Sole proprietorships (firms with no employees) appear and disappear at astonishing rates, in particular in

the ICT sector. In this size category, only Denmark and the other two Baltics countries had higher birth rates among OECD economies for which comparable data were available for 2016. Sole proprietorships are important among young manufacturing firms, making up 59% of 1-year-old firms. Skills are relatively well-matched in Estonia, a further indication that business dynamics are fairly good (Adalet McGovan and Andrews, 2015).

Figure 33. Business dynamics are decent (2016)

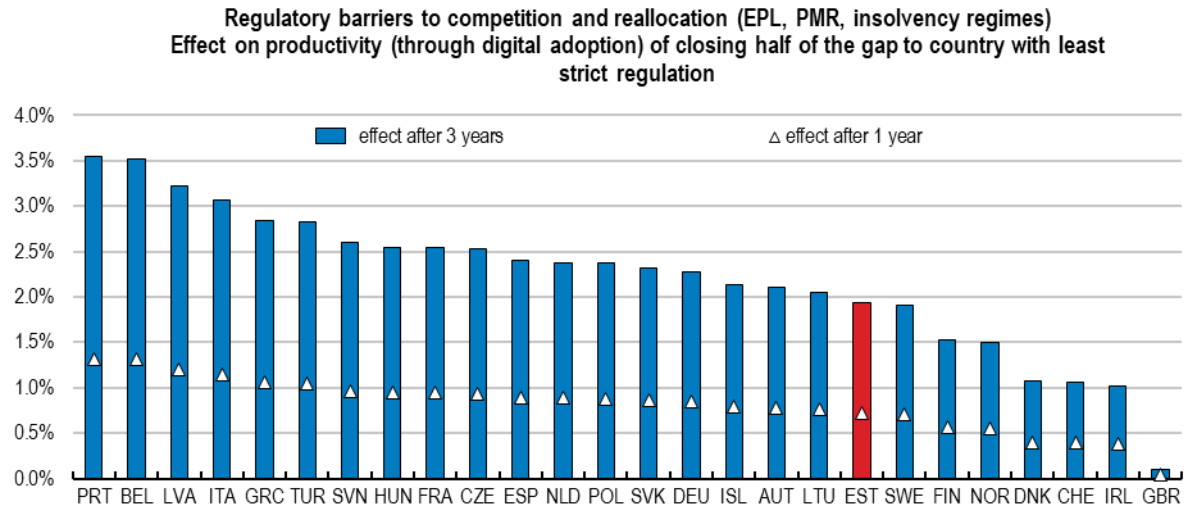


Note: The birth rate is the ratio of newly created firms in the given year to the number of already existing firms, while the death rate is the ratio of firm closures in a given year to the number of existing firms.
Source: OECD SDBS Business Demography Indicators (ISIC Rev. 4).

Regulations are lean, but with some weaknesses

72. Product market- and employment protection regulations are relatively lean, and Estonia is one of the countries most open to digital trade in the world (see above). However, there is room to boost productivity by streamlining regulations, notably by streamlining the insolvency regime, but also by avoiding command-and-control regulations and reducing public ownership in network sectors (Figure 34).

Figure 34. Some room to boost productivity by streamlining regulations remains



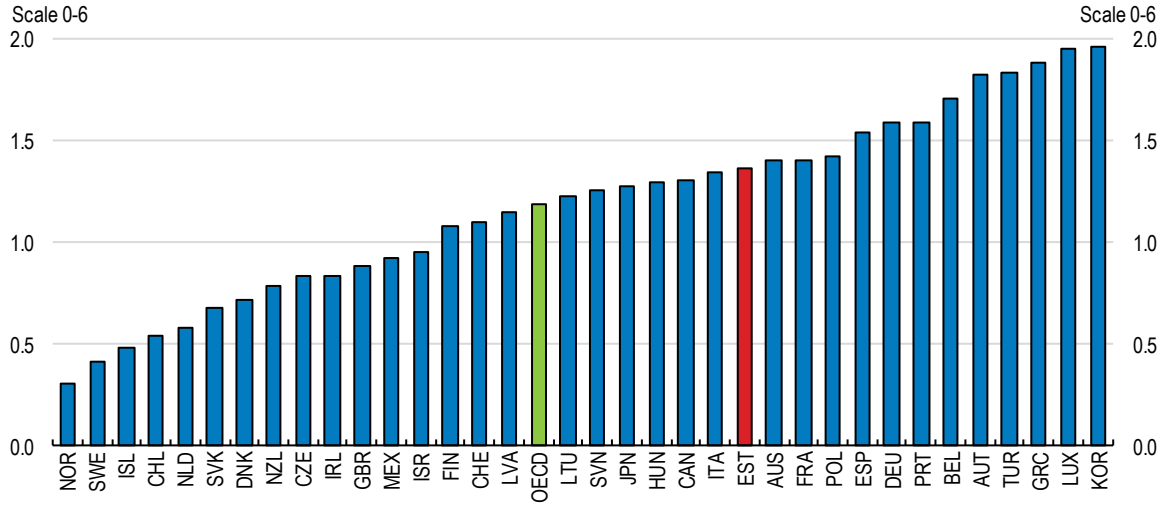
Note: Estimated effect on multi-factor productivity (MFP) of the average firm from reducing employment protection legislation (EPL) on regular contracts, reducing administrative burdens on start-ups (a subcomponent of the OECD PMR indicator) and improving the insolvency regime, as measured by the indicator in Adalet McGowan and Andrews (2017). For each of these indicators, it is assumed that half of the gap to the country with the least strict regulation in the sample is closed.
Source: Sorbe *et al.*, 2019.

73. Estonia's insolvency regime is quite stringent. An efficient insolvency framework supports investment and avoids that capital becomes trapped in low-productivity firms. Adalet McGovan et al. (2017) find that reforms of insolvency regimes reducing barriers to restructuring can facilitate technological diffusion, and that such reform can give a sizeable boost to productivity growth. Excessively low creditor protection could on the other hand undermine credit supply. An OECD indicator on insolvency regimes shows that Estonia has ample room for improvement in terms of the framework and outcomes of corporate insolvency proceedings. The OECD Economic Survey of Estonia 2017 outlines avenues to improve the insolvency regime. Giving creditors the right to initiate restructuring (rather than liquidation alone) would increase recovery rates and the chances of the company's survival. Early-warning mechanisms, and pre-insolvency regimes permitting swifter out-of-court settlement could be introduced. Additionally, the length of the period in insolvency during which creditors cannot continue debt collection, thereby allowing for restructuring of the business, should be shortened, like in some other OECD countries, including Germany, Ireland and the United Kingdom. Finally, to encourage capital injections required to facilitate the reorganisation of firms, international best practice suggests that new financing should have priority over unsecured creditors (OECD Economic Survey of Estonia, 2017; Adalet McGovan et al., 2017).

74. Overall regulations of product markets are relatively lean in Estonia, as measured by the OECD product-market regulation (PMR) indicator, but there is room for improvement in some aspects. In particular, before adopting new regulations, regulators are not required to assess alternative policy instruments (be it regulatory or non-regulatory) vis-à-vis the proposed regulation. The lack of that requirement risks the introduction of regulations that might not lead to the most favourable outcomes, thereby weighing on efficiency of the system. Similarly, no guidance has been issued on using alternatives to traditional regulation. Over two-thirds of OECD countries require the assessment of alternative instruments and issue guidance on the alternatives to traditional regulation. Reflecting this regulatory policy weakness, command and control regulation is more common in Estonia than the OECD average (Figure 35).

Figure 35. Command and control regulation is more common than in other OECD countries

Command and control sub-index of the PMR indicator, 2018

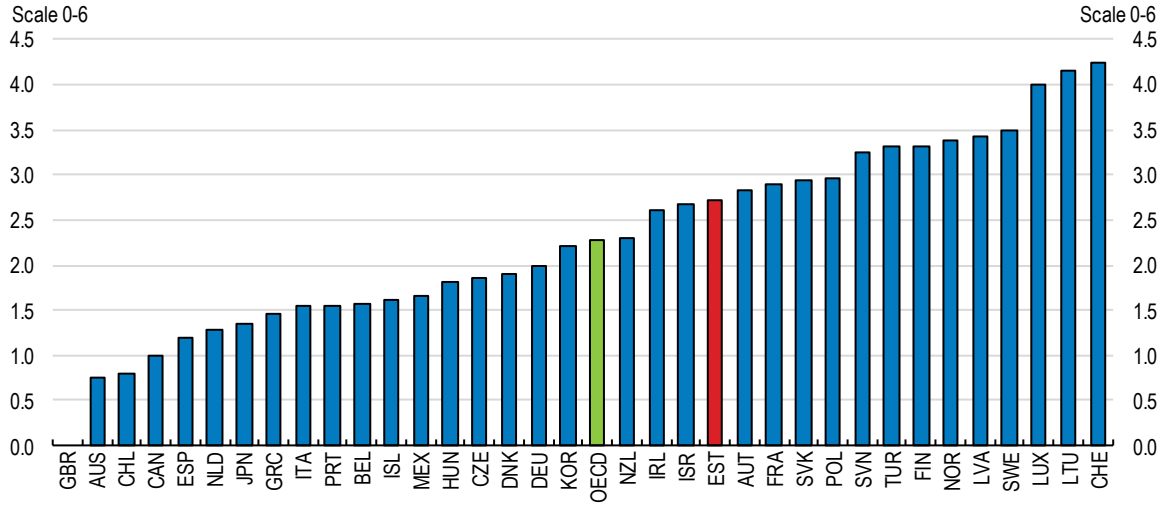


Note: The Product Market Regulation sub-indicator of command-type regulation covers various regulations of coercive type such as shop opening hours, universal service provision, backhauling, intermodal operations, advertising and restrictions on the legal form of business in eight sectors. The values of the indicator range between 0 and 6, with higher values indicating more stringent regulation.
Source: OECD Product Market Regulation database.

75. The Estonian government's involvement in network industries is above that of the OECD average (Figure 36). In particular, in the four network industries of electricity generation, post, air and rail transport, government ownership in the largest firm is very high. In the generation, import, transmission, distribution and supply of electricity, government fully owns the largest firm. While in many network industries several competitors could hardly survive in a small market like Estonia, private shareholders could exert pressure to improve efficiency. Also, at least some segments in certain network industries could have more competition, for instance in electricity generation. Multiple railway operators may also be feasible. Greater competition in those industries would lift overall productivity. Where competition or other private participation is not feasible, better governance of the incumbent public enterprise could also bring about efficiency gains. While the lack of competition weighs on potential efficiency gains, single ownership and a single standard (instead of potentially numerous, mutually incompatible standards) provides opportunities to pursue digitalisation in those network industries. A frontier country in services digitalisation, China, for instance, is now piloting paperless railroad ticketing in certain regions. Single ownership of railways will make it easier to extend e-tickets to the whole country.

Figure 36. Government ownership in network sectors is high

Government involvement in network sectors sub-index of the PMR indicator, 2018



Note: The Product Market Regulation indicators takes values between 0 and 6, with higher values reflecting greater restrictiveness.
Source: OECD Product Market Regulation database.

76. Estonia also strives to become frontrunner in setting up regulatory systems for future production. In March 2018, Estonia announced that it will prepare a bill to allow the use of fully autonomous information systems in all areas of life. The major task is to ensure the clarity of the law around responsibility of the decisions made by such systems, as well as the mode of supervision. An expert group made up of government officials, academicians and business sector participants was launched in the same year to prepare the bill by June 2020. The national AI strategy 2019-21 has already been put in place. The Ministry of Finance and the Financial Supervisory Authority consider implementing a regulatory sandbox for the Fintech industry, where certain regulatory requirements are temporarily waived, so that enterprises can deploy their innovative solutions in real-life market conditions. This approach holds considerable promise for companies, but also for regulators, who can draw experience for future regulatory invention.

Overcoming lack of scale and increasing awareness of digital potential

77. Small companies can face structural impediments to adopt certain digital technologies, since some of those technologies can entail high investment costs. Indeed, the share of firms using enterprise software, cloud computing or big data increases nonlinearly in firm size. In the wood industry, which is an internationally competitive industry in Estonia for example, the minimum threshold to invest in ICT is an annual turnover of EUR 10 million. Considering that the average annual turnover of manufacturing firms with at least 10 employees is around EUR 12 million (as of 2016) and that such firms make up only 8% of the business universe, affordability of such goods and services is the privilege of a couple of thousand firms.. Agglomeration economies might also play a role, with low population density and a lack of relevant expertise outside of the Tallinn area. However, as outlined above, the size distribution of Estonian companies is comparable to other OECD countries, and a number of small OECD countries, like Ireland, Lithuania and the Nordics face comparable structural conditions, but their non-ICT sectors are among the most digitally advanced in the OECD.

78. A small home market in the geographic periphery of the European Union may also pose a barrier. Home-bred companies in traditional sectors may find it challenging to build the necessary scale to take on the investment costs of expanding to other countries, and the investment cost of digitalising back- middle-

and front-office functions may be perceived as daunting with a limited number of suppliers, employees and customers. A traditional dependence on cheap labour may also hold back automation. Even though high wage growth lately poses a challenge to Estonia's competitiveness, it may yet prove to be a boon to overall productivity to the extent it forces companies to seek ways to automate and digitalise to stay competitive.

79. Increased cooperation could be a way to overcome investment costs of adopting digital technologies and expanding beyond national borders. As an example, small-scale furniture producers who each already export to a limited set of foreign markets could share their existing networks outside of Estonia's borders and cooperate on exporting their products under common marketing- sales- and distribution platforms. Mergers and joint operations to reach critical investment thresholds are possible ways of cooperation, as is standardisation, easing communication across various software packages. Employer- and labour organisations provide platforms for networking and cooperation in countries such as the Nordics and Germany, but a weak culture of cooperation may stand in the way in Estonia, where labour unions have the lowest coverage in the OECD, and employers' organisation rate is at 25% also one of the lowest in the OECD (OECD, 2017a). Strengthening unionisation could have advantages also in other areas, such as skill supply, as discussed above.

80. Greater participation in the European Strategic Cluster Partnerships would provide an avenue for Estonian SMEs to interact with technology centres both within clusters and across regional and sectoral silos. Estonian industry associations could for example facilitate or provide platforms for their members with smart solutions based on machine learning and AI to efficiently leverage data in real time. These could cover joint marketing, supplier interactions and customer support. The digital manufacturing on a shoestring initiative in the United Kingdom seeks affordable smart solutions for SMEs not only for encompassing digitalisation on the factory floor, but also in office functions and supplier interactions. In Estonia, such digitalisation support could be a next step following digital diagnostics by Enterprise Estonia. Singapore's Productivity Solutions Grant, which covers up to 70% of one-off costs of IT solutions and equipment, supports companies keen on adopting IT solutions and equipment to enhance business processes.

81. The lack of scale is compounded by a lack of awareness of potential gains, a prerequisite to motivate firms to adopt digital technologies. The Green Paper on Industrial Policy aims to increase entrepreneurs' awareness of the positive impact of digitalisation. Enterprise Estonia offers grants to manufacturing and mining firms covering the costs of digital diagnostics, performed by private consultancies to identify areas where digitalisation could and should be implemented in the company. The grants cover most of the costs of the diagnostics exercise and range between EUR 5 000-15 000. However, there are complaints about the high degree of bureaucracy when applying, only firms with annual sales over EUR 200 000 are eligible, and take-up rates of the various tools are not published. Reducing bureaucracy of the application process, reducing the firm size threshold, publishing take-up rates and disseminating success stories would increase appetite for this service.

Easier access to capital would foster productivity growth through digitalisation

82. Financing is not an obstacle to long-term investments among larger firms, but 18% of micro firms (less than 10 employees) and 12% of small and medium-size enterprises (SMEs) consider it a major obstacle. One in twenty Estonian SMEs consider access to finance as the single major issue (European Commission, 2018b). Even though these shares are lower than in Baltic peers, they are higher than in other Central and Eastern European economies, let alone Nordic countries.

83. The rejection rate of loan applications made by SMEs, a more meaningful indicator of access to finance, is more than double the EU average (11% vs. 5%) and so is the share of SMEs that do not apply for bank loans in the first place in fear of rejection (also 11% vs. 5% in the EU). Alternative financing methods are gaining space in Estonia to fill in for demand unmet by banks. Factoring has become the most

important source of financing for SMEs, followed by bank loans and internal funds (European Commission, 2018b).

84. To support SMEs' access to credit, the government offers credit guarantees, interest subsidies and maintains specialised financial institutions serving SMEs (OECD, 2019g). SMEs also have access to so-called industry loans for export-oriented firms in mining, processing manufacturing and electricity industries. Those loans are granted by SA KredEx, a foundation set up by the Ministry of Economic Affairs and Communications, and provided by banks. The loan can be up to 40% of the project cost and maximum EUR 2 million per project. A novelty of this measure introduced in 2018 is that it also supports investment in intangible assets, unlike the earlier so-called technology loans, which were limited to tangible assets. This change is of particular significance as investing in intangible capital is key to digitalisation (and Estonia so far have invested relatively little in intangible capital). KredEx also supports risk capital. Such government support is justified on the basis of market failures related to information asymmetry between banks and firms.

85. A major complaint by the business sector is the requirement of collateral for enterprise borrowing and collateral is most of the time real estate. That is why service companies, that are less likely to own fixed assets that can be collateralised, are more likely to consider financing as a major obstacle to long-term investment (12% vs. 10% in manufacturing). In particular, construction companies face difficulties in access to finance (19% of them view it as a major obstacle to long-term investment). In addition, the lack of internationally accepted collateral prevents overseas acquisitions and hence firm growth.

86. To overcome the lack of fixed assets to serve as collateral for borrowing from banks, a system and standards to accept intangible assets as collateral could be established. Given the strong performance in terms of registering trademarks and industrial design by Estonian companies, collateralising those could ease borrowing constraints. Korea is among the OECD countries with an effective system providing loans for purchasing, commercialising and collateralising intellectual property under the "Techno Banking" initiative by the Korean Development Bank. The Bank also established a collection fund for distressed intellectual property for the disposal of intangible assets. In additions, the government should promote alternative financing, including FinTech, to fill the funding gap, while keeping safe standards regarding consumer protection and predatory lending.

Innovation and R&D policies to foster digitalisation

87. Judging from internationally comparable indicators, entrepreneurial spirit is not lacking in Estonia. By the Global Entrepreneurship and Development Index, the country ranks 23rd, much higher than its ranking by per capita income. Furthermore, Estonia ranks 24th by the Global Innovation Index 2019 and even higher on innovation outputs (18th) (Cornell university, INSEAD, and WIPO, 2019). Estonia fares well in creative outputs, in particular the creation of mobile apps, where it ranks seventh. Creativity, however does not translate into intellectual property-related revenues from abroad, as they are only a negligible share of services trade exports. Indeed, ICT-related patents are only a fraction of all patents. In trademarks and industrial design, in contrast, Estonia ranks 25th and 22nd, respectively. In general, the strictly innovation-related sub-indices appear the major weak point of the innovation ecosystem.

88. The Estonian Research, Development and Innovation Strategy 2014-20 set a target for R&D spending of 3% of GDP by 2020. This would not only reverse the decline in R&D spending starting in 2012, but would mean doubling of spending relative to recent years. The share of the higher education sector in R&D spending is particularly high, together with the government and non-profit sector make up over half of the total. However, many research projects are not related to real-life problems and therefore are likely to have little impact on productivity. R&D should not only be undertaken by universities but also by industries. While basic research is important and so is the freedom of researchers, part of government-sponsored research projects could be better linked to issues Estonia is facing and required to prove their

role in finding solutions for major bottlenecks. A description of major benefits of the project should also be required with possibly quantification of the benefits.

89. A major question is how to incentivise various units to work better together. Innovation vouchers in place since 2009 help SMEs establish their first contact with universities or other experts to develop innovative solutions. Development vouchers can then be used in the next step. Currently, all patents registered by academic staff or researchers are owned by the university or research institution they work for. Patenting activity could benefit from allowing individuals to share the return on patent commercialisation.

MAIN FINDINGS (key in bold)	RECOMMENDATIONS (key in bold)
Maximising complementarities between technologies, skills and policies	
High-performance work practices boost individuals' skill use at work, digital adoption and productivity performance. Their use in Estonia is around the OECD average.	**Implement a programme to improve managerial practices and organisational performance of firms with a strong element of network-building to disseminate good practice and mutual learning.**
The small scale of firms may pose a barrier to investments in digital technologies and internationalisation.	Support industrial associations in providing platforms and developing affordable smart solutions in areas such as joint marketing, supplier interactions and customer support.
Broadband connection speed is low in international comparison.	Provide better coverage for ultra-fast broadband at an affordable cost, including subsidising last-mile rollout for smaller enterprises.
Some enterprises may not undertake digital diagnostics in fear of bureaucracy of the process. The potential benefits of the diagnostics are not well known.	Reduce bureaucracy in the application process for digital diagnostics – an exercise to determine digital needs of companies -- to increase take-up rates and publish respective statistics and success stories to make the initiative more attractive.
Making the most of skills	
The organisation, content and quality of the teaching of digital skills varies between schools, and Teachers do not feel sufficiently prepared to teach digital skills and use digital tools.	**Strengthen the quality and relevance of teachers' training and professional development in teaching digital skills.**
An overwhelming majority of ICT specialists are men, reflecting early educational choices.	**Tailor ICT classes and voluntary ICT hobby activities to better match the interests of both girls and boys from the early stages of compulsory school and in early childhood education and care.**
People with low education and skills are more likely to work in jobs more vulnerable to automation and digitalisation.	**Continue to scale up and improve access to active labour market policies, notably up-skilling activities for the unemployed, the disabled and those in high risk of unemployment.**
Many unemployed are not covered by unemployment insurance owing to its stringent conditions and hence cannot benefit of active labour market programmes.	**Relax eligibility conditions for unemployment insurance.**
Estonian companies are little involved in vocational education and training and the continuous training of own employees.	**Strengthen cooperation between the public sector, labour unions and employers to boost their engagement in skill supply, including vocational education and training and continuous learning.**
A large share of internet users are either unaware of or passive towards IT security and privacy issues.	Integrate digital security and privacy risk management and awareness throughout the educational system and in adult education activities related to digital skills.
The threshold of two times the average wage may be too high to attract highly qualified workers, notably young ones in entry-level positions.	Consider to soften rules for high-skilled immigration.
Boosting digital dissemination in a market-friendly environment	
Access to finance is an obstacle to long-term investment for smaller firms and they are rejected or do not apply for loans in fear of rejection.	**Promote alternative financing to fill the funding gap for SMEs.**
The large number of planning documents at the national and sectoral levels contain overlap and industry digitalisation is not sufficiently emphasised.	**Formulate policies for industry digitalisation in a holistic way as a means of productivity catch-up and reflect those in government planning documents. Monitor implementation.**
Costly and slow insolvency proceedings hold back business dynamics.	Reduce the time and costs associated with insolvency and develop early warning mechanisms and opportunities for out-of-court settlements.
Collateral in the form of fixed assets is usually required when borrowing from banks, but other assets, such as intellectual property, are not accepted.	Establish a system and standards to accept intangible assets as collateral.
Regulators are not required to assess alternative policy instruments before adopting new regulations.	Before adopting new regulations, require the regulators to assess alternative policy instruments.
The government fully owns or holds nearly all shares in the largest firm in electricity generation, posts, air and rail transport.	Introduce more competition into electricity generation, posts, air and rail transport where feasible.
Research funds are often used for projects without much connection with Estonia.	Direct part of government-sponsored research funds to projects finding solutions for major bottlenecks in the country.
Patents developed in universities or research institutions belong to the institutions, without material benefits for the inventors, thereby reducing patenting incentives.	Allow individual researchers to share the return on patent commercialisation.

References

Ali-Yrkkö, J., J. Mattila and T. Seppälä (2017), "Estonia in global value chains", *ETLA – The Research Institute of the Finnish Economy Reports No. 69*, available at https://www.etla.fi/wp-content/uploads/ETLA-Raportit-Reports-69.pdf accessed on 17 July, 2019.

Adalet McGowan, M. and D. Andrews (2017), "Skills mismatch, productivity and policies: Evidence from the second wave of PIAAC", *OECD Economics Department Working Papers*, No. 1403, OECD Publishing, Paris, https://doi.org/10.1787/65dab7c6-en.

Adalet McGowan, M. and D. Andrews (2015), "Labour Market Mismatch and Labour Productivity: Evidence from PIAAC Data", *OECD Economics Department Working Papers*, No. 1209, OECD Publishing, Paris, https://doi.org/10.1787/5js1pzx1r2kb-en.

Adalet McGowan, M., D. Andrews and V. Millot (2017), "Insolvency Regimes, Technology Diffusion and Productivity Growth : Evidence from Firms in OECD Countries", *OECD Economics Department Working Papers*, No. 1425, OECD Publishing, Paris, https://dx.doi.org/10.1787/36600267-en.

Andrews, D., G. Nicoletti and C. Timiliotis (2018), "Digital technology diffusion: A matter of capabilities, incentives or both?", *OECD Economics Department Working Papers*, No. 1476, OECD Publishing, Paris, https://dx.doi.org/10.1787/7c542c16-en.

Andrews, D. C. Criscuolo and P. Gal (2016), "The Best versus the Rest: The Global Productivity Slowdown, Divergence across Firms and the Role of Public Policy", *OECD Productivity Working Papers*, No. 5.

Bloom *et al.* (2019), "What Drives Differences in Management Practices?", *American Economic Review*, Vol. 109(5), https://doi.org/10.1257/aer.20170491.

Bloom, N., C. Genakos, R. Sadun and J. Van Reenen (2012a), "Management Practices Across Firms and Countries", *NBER Working Papers*, No 17850.

Bloom, N., R. Sadun and J. Van Reenen (2012b), "Americans Do IT Better: US Multinationals and the Productivity Miracle", *American Economic Review*, Vol. 102(1), http://dx.doi.org/10.1257/aer.102.1.167.

Bloom, N. and J. Van Reenen (2007), "Measuring and Explaining Management Practices Across Firms and Countries", *Quarterly Journal of Economics*, 122 (4), pp. 1351-1408.

Bailin Rivares, A., P. Gal, V. Millot and S. Sorbe (2019), "Like it or not? The impact of online platforms on the productivity of incumbent service providers", *OECD Economics Department Working Papers,* No. 1548. https://doi.org/10.1787/080a17ce-en.

Benkovskis, K., et al. (2017), "Export and productivity in global value chains: Comparative evidence from Latvia and Estonia", *OECD Economics Department Working Papers*, No. 1448, OECD Publishing, Paris, https://doi.org/10.1787/cd5710c4-en.

Boubtane, E. and J.-C. Dumont (2013), "Immigration and Economic Growth in the OECD Countries 1986-2006: A Panel Data Analysis", *Documents de Travail du Centre d'Economie de la Sorbonne*, No. 2013.3.

Calvino, F. et al. (2018), "A taxonomy of digital intensive sectors", *OECD Science, Technology and Industry Working Papers*, No. 2018/14, OECD Publishing, Paris, http://dx.doi.org/10.1787/f404736a-en.

Cornell University, INSEAD, and WIPO (2019), *The Global Innovation Index 2019: Creating Healthy Lives—The Future of Medical Innovation*, Ithaca, Fontainebleau, and Geneva.

ECIPE (2018), *Digital Trade Restrictiveness Index 2018*, European Center for International Political Economy, Brussels.

Eesti Pank (2019*), Estonian Economy and Monetary Policy*, No 2 2019, Bank of Estonia, Tallinn.

Estonian Association of Information Technology and Telecommunications (2018), *Vision Smart Estonia – Vision of the Estonian Association of Information Technology and Telecommunications of Information Society in 2030,* Tallinn.

Estonian Association of Information Technology and Telecommunications (2014), *Information and Communication Technology Sector's Vision of Estonian Information Society in 2020,* available at https://www.itl.ee/public/files/Visioon2020_eng.pdf accessed on June 17, 2019.

E-Estonia Guide (2018), available at https://e-estonia.com/wp-content/uploads/eestonia-guide-2018.pdf downloaded on May 28, 2019.

European Commission (2019a), *Digital Economy and Society Index (DESI), Country Report Estonia*, Brussels.

European Commission (2019b), *Country Report Estonia*, Commission Staff Working Document, SWD(2019) 1005 final, Brussels.

European Commission (2018a), *E-Government Benchmark 2018 – Securing E-government for all*, available at https://ec.europa.eu/newsroom/dae/document.cfm?doc_id=55487 accessed on June 4, 2019.

European Commission (2018b*), Integration of immigrants in the European Union*, special Eurobarometer survey 469, Brussels.

European Commission (2018c), *Digital Economy and Society index 2018*, Country Report Estonia, Brussels.

European Commission (2018d), *SME Access to Finance Conditions – 2018 SAFE results – Estonia,* available at https://ec.europa.eu/docsroom/documents/32762 accessed on 17 July, 2019.

Eurostat (2019a), *Annual enterprise statistics*, database (Accessed 26 July 2019), Luxembourg.

Eurostat (2019b), *Digital economy and society*, database (Accessed 25 July 2019), Luxembourg.

Fabling, R. and A. Grimes (2016), "Picking up speed: Does ultrafast broadband increase firm productivity", Motu Working Paper *16-22,* available at http://conference.iza.org/conference_files/MacroEcon_2017/fabling_r7010.pdf accessed on 21 June, 2019.

Ferencz, J. (2019), "The OECD Digital Services trade Restrictiveness Index", *OECD Trade Policy papers No. 221.* http://dx.doi.org/10.1787/16ed2d78-en.

Gal, P. et al. (2019), "Digitalisation and productivity: In search of the holy grail – Firm-level empirical evidence from EU countries", *OECD Economics Department Working Papers*, No. 1533, OECD Publishing, Paris, https://dx.doi.org/10.1787/5080f4b6-en.

Government of Estonia (2018), *Digital Agenda 2020 for Estonia*, Updated 2018 (summary), Government of the Republic of Estonia, Tallinn.

Gregory, T., A. Salomons and U. Zierahn (2019), "Racing With or Against the Machine? Evidence from Europe", *IZA Discussion Paper*s, No. 12063, IZA Institute of Labor Economics, http://ftp.iza.org/dp12063.pdf.

Grundke, R. et al. (2018), *"Which skills for the digital era?: Returns to skills analysis"*, *OECD Science, Technology and Industry Working Papers*, No. 2018/09, OECD Publishing, Paris, http://dx.doi.org/10.1787/9a9479b5-en.

ITF (2020), *What future for people and goods mobility in Estonia - Input study for the Estonian transport and mobility master plan*, forthcoming, ITF Publishing, Paris.

ITU (2019), *Global Cybersecurity Index 2018*, International Telecommunication Union, Geneva.

Männasoo, K., J. Pareliussen and A. Saia (2020), "Individuals' digital capacity and labour market outcomes: Comparative evidence from Europe", *OECD Economics Department Woking Papers, OECD Publishing*, Paris (forthcoming, working title).

McKinsey Global Institute (2019), *Notes from the AI Frontier – Tackling Europe's gap in digital and AI,* available at https://www.mckinsey.de, accessed on 17 July, 2019.

Ministry of Economic Affairs and Communications (2019), *Cybersecurity strategy*, Republic of Estonia, Tallinn.

Ministry of Economic Affairs and Communications (2013), *Digital Agenda 2020,* available at https://www.itl.ee/public/files/DigitalAgenda2020_Estonia_ENG.pdf accessed on June 17, 2019.

Mosiashvili, N. (2019), "Productivity implications of ICT Skill Shortage in the Digital Era – Evidence from Estonia", *Department of Economics and Management*, Université Paris-Est Créteil (UPEC), forthcoming.

Nedelkoska, L. and G. Quintini (2018), "Automation, skills use and training", *OECD Social, Employment and Migration Working Papers*, No. 202, OECD Publishing, Paris, https://doi.org/10.1787/2e2f4eea-en.

OECD (2019a), *OECD Economic Outlook*, Volume 2019 Issue 1, OECD Publishing, Paris, https://doi.org/10.1787/b2e897b0-en.

OECD (2019b) "The Human Side of Productivity: Setting the Scene", *Conference Background Paper for the 4th Annual Conference of the Global Forum on Productivity*, Sydney, Australia.

OECD (2019b), *OECD Skills Outlook 2019: Thriving in a Digital World*, OECD Publishing, Paris, https://doi.org/10.1787/df80bc12-en.

OECD (2019c), *Going Digital: Shaping Policies, Improving Lives*, OECD Publishing, Paris, https://dx.doi.org/10.1787/9789264312012-en.

OECD (2019d), *OECD Employment Outlook 2019: The Future of Work*, OECD Publishing, Paris, https://doi.org/10.1787/9ee00155-en.

OECD (2019e*), Measuring the Digital Transformation: A Roadmap for the Future*, OECD Publishing, Paris, https://doi.org/10.1787/9789264311992-en.

OECD (2019f), *Financing SMEs and Entrepreneurs 2019: An OECD Scoreboard*, OECD Publishing, Paris. https://doi.org/10.1787/fin_sme_ent-2019-en.

OECD (2018a), *Education at a Glance 2018: OECD Indicators*, OECD Publishing, Paris, https://doi.org/10.1787/eag-2018-en.

OECD (2018b), *OECD Tax-Benefit Model: Description of policy rules for 2018, Estonia*, http://www.oecd.org/els/benefits-and-wages.htm (accessed on 2 April 2019).

OECD (2018c), *The Future of Social Protection: What Works for Non-standard Workers?*, OECD Publishing, Paris, https://dx.doi.org/10.1787/9789264306943-en.

OECD (2017a), *OECD Economic Surveys: Estonia 2017*, OECD Publishing, Paris, https://dx.doi.org/10.1787/eco_surveys-est-2017-en.

OECD (2017b), *OECD Employment Outlook 2017*, OECD Publishing, Paris, https://doi.org/10.1787/empl_outlook-2017-en.

OECD (2016a), *PISA 2015 high performers, Estonia country note*, OECD Publishing, Paris.

OECD (2016b), *OECD Employment Outlook 2016*, OECD Publishing, Paris, https://doi.org/10.1787/empl_outlook-2016-en.

OECD (2015), *OECD Public Governance Reviews: Estonia and Finland: Fostering Strategic Capacity across governments and Digital Services across Borders*, OECD Publishing, Paris. http://dx.doi.org/10.1787/9789264229334-en.

OECD (2014), *Migration policy debates*, No. 2, OECD Publishing, Paris.

Pareliussen, J. and N. Mosiashvili (2020), "Digital technology adoption, productivity gains in adopting firms and sectoral spill-overs – Firm-level evidence from Estonia", *OECD Economics Department Working Papers*, OECD Publishing, Paris, forthcoming.

Pellegrino, B. and L. Zingales (2017): “Diagnosing the Italian Disease”, *NBER Working Paper*s, No. 23964.

Praxis (2019a), *Social Protection of the unemployed in Estonia*, Report (English Summary), Tallinn.

Praxis (2019b), *Labour force and skills needs in cyber security in Estonia*, Report (English Summary), Tallinn.

Praxis (2017*), ICT Education in Estonian schools and kindergartens*, Report (English Summary), Tallinn.

Schwellnus, C., et al. (2019), "Gig economy platforms: Boon or Bane?"*, OECD Economics Department Working Papers,* No. 1550, OECD Publishing, Paris, https://doi.org/10.1787/fdb0570b-en.

Sorbe, S. et al. (2019), “Digital Dividend: Policies to harness the potential of digital technologies”, *Economic Policy Papers*, No. 26, OECD, https://www.oecd-ilibrary.org/docserver/273176bc-en.pdf?expires=1554131573&id=id&accname=ocid84004878&checksum=5B1A9B6F5813C1679AD2EFE1603BA206 (accessed on 1 April 2019).

Statistics Estonia (2019), *Population projection until 2080, 2020-2080*, database (accessed 24 July 2019), Tallinn.

Valdani Vicari and Associates and Wik Consult (2018), *Monitoring Progress in National Initiatives on Digitising Industry, Country Report, Estonia,* manuscript.

Work in Estonia (2019), workinestonia.com (website, accessed 19 July 2019).