



UKRAINE'S INTEGRATION INTO THE EU'S DIGITAL SINGLE MARKET

Potential Economic Benefits

Pavlo Iavorskyi
Svitlana Taran
Oleksandr Shepotylo
Oleksii Hamaniuk

Analytical report

Kyiv, 2020

Acknowledgments

This report was prepared by the team of the Trade+ International Trade Research Centre at the Kyiv School of Economics in partnership with the Ukrainian Centre for European Policy at the request of the Ministry of Digital Transformation of Ukraine and with the support of the International Renaissance Foundation. The team of authors consists of Pavlo Iavorskyi, Svitlana Taran, Oleksandr Shepotylo, and Oleksii Hamaniuk. The team of the Ukrainian Centre for European Policy consists of Liubov Akulenko and Dmytro Naumenko.

We would like to express our gratitude to the experts who took part in the survey on regulatory barriers to digital trade in Ukraine – Andrii Melashchenko, Oksana Prykhodko, Viacheslav Shtanko, Mykyta Polatayko, Dmytro Batsenko, and Nadiia Kostryba.

We are also very grateful to Yuliya Garyacha, Andrii Melashchenko, Iryna Kosse, Elena Besedina, Anastasiia Hrechko, and Dmytro Naumenko for their comments.

We are grateful for the opportunity to contribute to the development of the Ukrainian economy and Ukraine’s integration into the European Union.

The report was produced by the team of Trade+, International Trade Research Center at Kyiv School of Economics, in partnership with the Ukrainian Centre for European Policy at the request of the Ministry of Digital Transformation of Ukraine and with the support of the International Renaissance Foundation within the framework of “Benefits assessment for Ukraine and EU on the integration of Ukraine in the EU Digital Single Market” project. The opinions expressed are those of the authors and do not necessarily reflect the views of the International Renaissance Foundation and the Ministry of Digital Transformation of Ukraine.

Design and layout: **Oleksandr Ivanov**

© 2020, NGO Ukrainian Centre for European Policy



Ministry of
Digital Transformation
of Ukraine



UKRAINIAN CENTRE
FOR EUROPEAN
POLICY



Kyiv
School of
Economics



Trade+
at Kyiv
School
of Economics



INTERNATIONAL
RENAISSANCE
FOUNDATION

Table of Contents

List of abbreviations.....	4
Executive Summary.....	5
Introduction.....	8
Part 1. Integrating Ukraine into the EU's Digital Single Market.....	9
Key Advantages of Integration into the EU's DSM.....	9
Ukraine in International Digital Development Ratings.....	10
Part 2. Methodology.....	13
Calculation of the Digitalization Index and the Digital Services Trade Restrictiveness Index.....	13
Designing Scenarios for Ukraine's Integration into the EU's DSM.....	16
Assessment of the Impact of Digitalization on the Productivity and Economic Growth of Ukraine.....	17
Assessment of the Impact on International Trade in Goods and Services.....	18
Assessment of the Welfare Effects.....	20
Data Description.....	20
Part 3. Empirical Results.....	21
Assessment of the Impact of Digitalization on Productivity and Economic Growth of Ukraine.....	25
Assessment of the Impact on Bilateral Trade in Goods and Services between Ukraine and the EU.....	25
Assessment of the Welfare effects for Ukraine and the EU.....	29
Part 4. Conclusions.....	31
Annexes.....	33

List of abbreviations

GDP – Gross Domestic Product

EU – European Union

DSM – Digital Single Market

ICT – Information and Communications Technology

IBA – International Business Activity

OECD – Organization for Economic Co-operation and Development

UN – United Nations

BIC – Broadband Internet Connection

DESI – Digital Economy and Society Index

EGDI – E-Government Development Index

NRI – Network Readiness Index

Digital STRI – Digital Services Trade Restrictiveness Index

Executive Summary

For Ukraine, integration into the EU's DSM is a tool for deepening its economic integration into the EU's internal market, as well as facilitating the digitalization of Ukraine in accordance with European and international standards. It involves expansion of the mutual access to online markets and digital services, as well as Ukraine's application of the EU's common rules, standards and procedures in the digital sphere, including those concerning registration of electronic contracts, electronic payments and settlements, distribution of digital content, copyright registration, provision of cross-border digital services, protection of consumer rights on the internet etc.

This study quantifies the potential economic benefits of Ukraine's integration into the EU's DSM, which includes two main channels of influence – i. e. regulatory approximation in the digital sphere between Ukraine and the EU, which will reduce regulatory restrictions on digital trade between Ukraine and the EU, and acceleration of digital transformation in Ukraine.

For the purposes of this study, we calculated a Composite Digitalization Index and Digital Services Trade Restrictiveness Index for Ukraine for 2016-2018.

The results of the calculation of the Digitalization Index show that the current level of digital development in Ukraine is far below the EU average. Ukraine also lags behind the new EU Member States¹, which have a lower level of economic and digital development compared to the other EU countries. In addition, it was discovered that the level of digital services trade restrictiveness in Ukraine is much higher than the EU average. The regulatory differences in the digital sphere between Ukraine and the EU increase the cost of cross-border digital transactions between countries.

For Ukraine, most barriers are related to cross-border electronic payments and settlements, protection of intellectual property rights on the Internet, cross-border electronic transactions (for example, the divergence of the national

requirements for foreign trade agreements, including electronic ones, from international practices and standards, lack of practical mechanisms for the application of the electronic digital signature in foreign trade contracts, lack of mutual recognition of electronic identification and electronic trust services between Ukraine and major trading partners etc.), other barriers (requirements for the use of local software and cryptography, etc.). These regulatory restrictions significantly hinder the development of cross-border cooperation and Ukraine's integration into the European and global digital space.

Integration into the EU's DSM will expand access to the EU's online markets and advanced digital technologies, which will accelerate the development of Ukraine's digital economy in line with European standards and contribute to Ukraine's gradual approximation to the European level of digital development. In addition, regulatory approximation to the EU digital law will help reduce regulatory restrictions on digital trade between Ukraine and the EU to the level of the EU Member States' restrictions through the use of common principles, standards and compatible systems.

In the event of Ukraine's integration into the EU's DSM, Ukraine's regulatory environment and digital development are expected to gradually approach the EU average. Hence, three integration scenarios were considered – bottom, medium, and top – implying different levels of Ukraine's approximation to the law and digital development of the EU.

The study assesses the effects of the implementation of EU DSM integration scenarios on the bilateral trade in goods and services between Ukraine and the EU, Ukraine's GDP growth and welfare effects for Ukraine and EU countries through the use of the Cobb-Douglas production function and the gravity model of international trade. These benefits of integration are ensured through the growth of productivity of the Ukrainian economy and reduction of transaction and trade costs in trade in goods and services between Ukraine and the EU.

The quantitative assessment of the potential economic benefits of Ukraine's integration into the EU's DSM consists of the following stages:

¹) Our sample includes the following new EU members: Poland, Lithuania, Latvia, Estonia, Slovakia, the Czech Republic, Romania, Bulgaria, Slovenia, and Croatia.

Assessment of the impact of digitalization on productivity and economic growth:

- Assessment of the Cobb-Douglas production function, which reflects the impact of digitalization on productivity and economic growth (2016-2017):
 - obtaining the value of the coefficient of the effects of digitalization on economic growth, taking into account the current level of digitalization in Ukraine;
 - calculation of the potential levels of Ukraine's GDP growth according to the given scenarios of Ukraine's digitalization improvement.

Assessment of the impact on international trade in goods and services consists of 3 steps:

- Estimation of gravity models for exports of goods and services with Ukraine's current level of digitalization and the regulatory differences in the digital sphere between Ukraine and other countries over the medium term (2016-2018):
 - calculating the coefficients of the effect of independent variables on the dependent variable.
- Estimation of the gravity model for exports of goods and services for the last available period (2018) under the modified level of Ukraine's digitalization and regulatory differences in the digital sphere between Ukraine and other countries, and fixed coefficients of the effect of independent variables on the dependent variable, which were obtained at the previous stage:
 - calculation of potential levels of exports of goods and services from Ukraine to the EU and from the EU to Ukraine according to the given scenarios of changes in the level of regulatory differences in the digital sphere between Ukraine and other countries;
 - taking into account changes in the level of digitalization of Ukraine's economy under the given scenarios using estimation of the effects of digitalization on Ukraine's productivity and economic growth.
- Calculation of the level of change in the scope of exports of goods and services due to Ukraine's potential regulatory approximation to the EU in the digital sphere and overall improvement of the level of digitalization of Ukraine's economy – as the

difference between real and potential scope of trade.

Assessment of the welfare effects for Ukraine and the EU:

- Estimation of changes in the countries' welfare under conditions of general equilibrium due to changes in prices for consumer goods resulting from lower barriers to digital trade, increased productivity and increased revenue of the country. The assessment took into account all the factors used in the gravity model.

According to our estimations, reduction of the barriers to digital trade between Ukraine and the EU and acceleration of Ukraine's digitalization will have a positive effect for both Ukraine and the EU:

- Acceleration of the digital transformation of Ukrainian economy will produce a positive effect on its productivity and economic growth. Digitalization is linked with general technological development and significantly accelerates it. Digital transformation is defined as the introduction of “a fusion of advanced technologies that integrates physical and digital systems and when combined with innovative business models and processes, leads to the creation of smart products, services and significant improvement of productivity”². According to our estimates, a 1%-increase in the digitalization of the Ukrainian economy and society may lead to an increase in Ukraine's GDP by 0.42%. Therefore, depending on the level of digitalization gradually approached by Ukraine within the EU's DSM, the cumulative positive impact on Ukraine's GDP may range from 2.4 to 12.1% (USD 3.1-15.8 billion³) of additional growth throughout the approximation period. That is, there is a significant potential for economic growth in Ukraine to be attained by increasing digitalization and productivity of various spheres of Ukrainian economy and society – including development of digital infrastructure and improving access to it, introduction of digital technologies in all areas of business, development of digital skills and competencies of citizens, and e-government. It is expected that Ukraine's integration into the EU's DSM will accelerate all these processes in Ukraine.

2) <https://eufordigital.eu/uk/digitising-industry-best-practices-to-promote-the-digital-transformation-of-smes-in-traditional-sectors-of-the-economy/>

3) Of Ukraine's 2018 GDP.

- Bringing Ukraine's regulatory environment and digital development closer to that of the EU by integrating Ukraine into the EU's DSM can increase the exports of services from Ukraine to EU countries by 7.6-12.2% (USD 302-485 million⁴) and the exports of goods by 11.8-17% (USD 2.4-3.4 billion⁵). At the same time, exports of services from the EU to Ukraine may increase by 5.7-9.1% (USD 191-305 million⁶) and exports of goods from the EU to Ukraine may go up by 17.7-21.7% (USD 4.1-5 billion⁷). This is the potential for a cumulative increase in the bilateral trade between Ukraine and the EU throughout the period of implementation of reforms aimed at regulatory and digital approximation of Ukraine to the EU. It includes the effect of reducing the overall level of non-tariff barriers to trade between Ukraine and the EU as a result of the digitalization of cross-border trade transactions and regulatory approximation to the EU in the digital sphere.
- Ukraine will benefit from reduced trade costs in bilateral trade with the EU due to reduced digital regulatory barriers – Ukraine's welfare may improve by 3.6-7.8%. The welfare effects for EU citizens are much smaller as compared to Ukraine but, for the most part, they are positive.

Given the fact that the role of digital technologies in international trade and economy is becoming increasingly more important, Ukraine is interested in integrating into the European digital space, because the development of Ukraine's trade and economy as a whole in all areas of business activity depends on it. According to the results of the study, there is a significant potential for trade intensification and growth of Ukraine's economy as a result of Ukraine's integration into the EU's DSM.

4) Of the services export volume from Ukraine to the EU in 2018 according to the State Statistics Service of Ukraine.

5) Of the goods export volume from Ukraine to the EU in 2018 according to the State Statistics Service of Ukraine.

6) Of the services export volume from the EU to Ukraine in 2018 according to the State Statistics Service of Ukraine.

7) Of the goods export volume from the EU to Ukraine in 2018 according to the State Statistics Service of Ukraine.

Introduction

The Ukrainian government has prioritized Ukraine's integration into the EU's Digital Single Market (DSM) within the sectoral integration with the EU. The Ukraine-EU Summit, held on October 6, 2020, emphasized the paramount importance of the digital sector in boosting its economic integration and regulatory approximation under the EU-Ukraine Association Agreement.

Implementation of the provisions of the Association Agreement between Ukraine and the EU, in particular the updated Annex XVII-3, will result in the introduction in Ukraine of the latest EU standards in the field of electronic communications. Ukraine is also gradually approximating its regulations with regard to other components of the EU's DSM – electronic identification, electronic payments and settlements, protection of intellectual property rights on the Internet, cybersecurity, protection of personal data, etc. These steps, in turn, ensure Ukraine's gradual integration into the EU's Digital Single Market, which will facilitate digital transformations within the country and open a new window of opportunity for individuals and businesses.

At the request of the Ministry of Digital Transformation of Ukraine, team of the Trade+ International Trade Research Centre at the Kyiv School of Economics in partnership with Ukrainian Centre for European Policy conducted a study to quantify the economic benefits of Ukraine's integration into the EU's DSM, namely its effects on economic growth, trade and welfare of Ukraine and the EU.

The quantitative estimates might be used by the Ministry to make informed decisions concerning digital transformations and their effective communication in Ukraine and during negotiations with the EU. Equally important is effective communication with the public about the benefits of Ukraine's integration into the EU's DSM.

The report has the following structure: Part 1 outlines the main components and benefits of integration into the European Union's (EU) Digital Single Market (DSM) and contains review of Ukraine's position in international digital economy development rankings. Part 2 elaborates on the details of the technical approach to assessing the economic effects of Ukraine's integration into the EU's DSM. It describes the methodology for assessing the impact of integration on international trade, productivity and GDP of Ukraine as well as welfare effects. Part 3 presents the results of our estimations in each area. Part 4 summarizes the key findings of the study.

Part 1. Integrating Ukraine into the EU's Digital Single Market

This Part elaborates on the key components and benefits of integration into the Digital Single Market (DSM) of the European Union (EU), as well as offers a review of Ukraine's position in international digital economy development rankings.

Key Advantages of Integration into the EU's DSM

The creation of the EU's Digital Single Market involves uniting the national markets of the Member States, applying common approaches and standards in the EU digital sphere, removing barriers to cross-border transactions that take place online, etc. It builds on the concept of the common market, initially intended to eliminate trade barriers between Member States and further developed into the concept of the internal market, defined as 'an area without internal frontiers in which the free movement of goods, persons, services and capital is ensured'.¹

The DSM covers areas and public policy issues such as: prohibition of unjustified geo-blocking, elimination of roaming charges, introduction of net neutrality guarantees, cross-border parcel delivery, electronic identification and trust services for electronic transactions in the internal market, safeguarding privacy, personal data and cybersecurity, protection of copyright and related rights in the digital single market, consumer protection in DSM, requirements for contracts for the supply of digital content and provision of digital services, measures to deploy high-speed electronic communications networks etc.².

The economic benefits of the EU's DSM include two key areas: 1) benefits of the single market – regulatory harmonisation and removal of barriers between Member States in the digital sphere, facilitation of cross-border digital trade in the EU; 2) advantages of digitalization – further promotion of digitalization in EU Member States,

increasing the use of digital technologies in the EU, development of digital public services and e-government³.

Removing barriers to digital cross-border trade increases the overall efficiency of the EU's internal market for goods and services. The creation of the DSM simplifies and reduces the cost of cross-border electronic transactions between Member States, improves cross-border access to online markets and new digital products and services for businesses and consumers. As a result, the benefits of the single market include lower prices, greater choice and enhanced convenience for consumers, and scale economies effects for businesses. In addition, the benefits of digitization include productivity gains, reduced transaction costs, product, service and process innovations, and enhanced EU competitiveness.⁴

Approximation to the EU's DSM has been identified as a priority area for Ukraine's sectoral integration into the EU. In addition, it is an important tool for deepening economic integration into the EU internal market, as well as facilitating the digitalization of Ukraine in accordance with European and international standards.

Integration into the EU's DSM involves expanding mutual access to online markets and digital services, as well as Ukraine's accession to common EU rules, standards and procedures for electronic contracts, electronic payments and settlements, distribution of digital content, copyright, cross-border digital services, consumer protection, etc. The key economic benefits of Ukraine's integration into the DSM

1) European Parliament (2018a), The ubiquitous digital single market, Fact Sheet, <http://www.europarl.europa.eu/factsheets/en/sheet/43/the-ubiquitous-digital-single-market>

2) European Parliament (2018a), The ubiquitous digital single market, Fact Sheet, <http://www.europarl.europa.eu/factsheets/en/sheet/43/the-ubiquitous-digital-single-market>

3) [https://www.europarl.europa.eu/RegData/etudes/STUD/2019/631044/IPOL_STU\(2019\)631044_EN.pdf](https://www.europarl.europa.eu/RegData/etudes/STUD/2019/631044/IPOL_STU(2019)631044_EN.pdf)

4) [https://www.europarl.europa.eu/RegData/etudes/STUD/2019/631044/IPOL_STU\(2019\)631044_EN.pdf](https://www.europarl.europa.eu/RegData/etudes/STUD/2019/631044/IPOL_STU(2019)631044_EN.pdf)

are associated with the expected reduction of barriers to digital trade with the EU due to the regulatory approximation of the countries in the digital sphere, as well as acceleration of Ukraine's digital transformation in line with European standards. Specifically, the benefits of Ukraine's integration into the DSM include:

- Increased productivity of Ukraine's economy through better access to advanced digital technologies and EU innovations, better organization and automation of production and business processes, and enhanced digital skills.
- Reduced costs of doing businesses and public services due to going paperless.
- Reduced trade costs for cross-border digital trade between Ukraine and the EU by reducing regulatory, information and organizational barriers, optimizing logistics, etc.
- Anti-corruption impact: improved quality, transparency and efficiency in the provision of public digital services and e-government (e-customs, e-transit system, etc.) due to implementation of European best practices.
- Accelerated development of new industries, innovative products and services, modern digital infrastructure and technologies in Ukraine, such as artificial intelligence, cloud platforms and services, big data, etc.⁵
- Increased consumer welfare: expanded access to digital innovative products and services, improving online consumer protection, etc.

At the same time, integration into the DSM entails obligations for Ukraine to approximate national legislation and standards, to ensure institutional and technical capacity, as well as interoperability of digital systems, to develop high-speed broadband communications infrastructure, increase public investment in physical e-government infrastructure, etc. For businesses, this will mean regulation under European rules aimed at improving consumer protection (including requirements for the processing of personal data, etc.), as well as increased competition from European companies in digital markets. However, these changes are necessary if Ukraine wants to build a common economic space with the EU and given the

growing impact of digital technologies on international trade and economy. Otherwise, the rapid development of digital market regulation in the EU may create additional regulatory barriers and disparities in the digital sphere, which will negatively affect the development of bilateral digital trade and the overall progress of economic integration and cooperation between our countries.

Ukraine in International Digital Development Ratings

The key international ratings assessing the level of development of information and communications technology (ICT) and the regulatory environment of countries (Table 1) are:

- United Nations e-Government Development Index (EGDI)
- WEF / WITSA Network Readiness Index (NRI)
- IMD World Digital Competitiveness Ranking (WDCR).

E-Government Development Index (EGDI) is calculated by the UN and used to measure the readiness and ability of national governments to use information and telecommunications technology to provide services to the public and businesses and apply them in the work of government⁶. It is a composite index with three components: the Online Services Index (OSI), the Telecommunications Infrastructure Index (TII) and the Human Capacity Index (HCI).

According to the EGDI index for 2020, Ukraine ranks 69th among 193 countries (with a total score of 0.7119) and is included in the group of countries with high level of e-government development. Ukraine received the lowest scores for Telecommunications Infrastructure (0.5942), Online Services (0.6824), and the highest for Human Capital (0.8591).

Compared to the previous EGDI rating (2018), in 2020 Ukraine improved its position (moved from 82th to 69th rank). Nevertheless, Ukraine is lagging behind its neighbouring EU Member States, belonging to the group of countries with very high level of e-government development (Poland, Hungary, Slovakia, Romania, Bulgaria, Latvia, Lithuania, etc.). In addition, many other neighbouring countries are also ahead of Ukraine in the overall EGDI ranking: the Russian

5) https://drive.google.com/file/d/12mfd0qO2Wob5UNLze29-HCC-ZtSUg3_q/view

6) [https://publicadministration.un.org/egovkb/Portals/egovkb/Documents/un/2020-Survey/2020%20UN%20E-Government%20Survey%20\(Full%20Report\).pdf](https://publicadministration.un.org/egovkb/Portals/egovkb/Documents/un/2020-Survey/2020%20UN%20E-Government%20Survey%20(Full%20Report).pdf)

Table 1. Ukraine in the international digital development rankings

	Ukraine's spot	Position of the EU and other neighbouring countries
United Nations E-Government Development Index EGDl, 2020	69 position among 193 countries	Estonia – 3, Lithuania – 20, Poland – 24, Russia – 36, Czech Republic – 39, Belarus – 40, Bulgaria – 44, Latvia – 49, Croatia – 51, Turkey – 53, Romania – 55, Georgia – 65, Moldova – 79.
Network Readiness Index (NRI), 2019	67 position among 121 countries	Estonia – 23, Lithuania – 31, Czech Republic – 30, Poland – 37, Latvia – 39, Croatia – 44, Romania – 47, Russia – 48, Bulgaria – 49, Turkey – 51, Belarus – 61, Moldova – 66, Georgia – 68.
World Digital Competitiveness Ranking (WDCR), 2020	60 position among 63 countries	Estonia – 29, Lithuania – 30, Poland – 33, Latvia – 36, Czech Republic – 37, Russia – 38, Bulgaria – 45, Romania – 46, Croatia – 51, Turkey – 52.

Federation (RF) is 36th, Turkey ranks 53rd, and Georgia is 65th.

Network Readiness Index maps the development of information and communications technology of countries based on their performances across 62 indicators⁷. The index includes 4 components: Technology (access, content, future technologies), People (individuals, businesses, governments), Governance (trust, regulation, inclusion) and Impact (economy, quality of life, SDG contribution).

In the NRI ranking for 2019, Ukraine ranked 67th among 121 countries⁸. Ukraine lags behind most of all regarding the following indicators: Future Technologies (82nd of 121), ICT Use by Government and Online Government Services (87th) and Regulatory Environment (72nd). It scored highest in terms of Content and Use of ICT by businesses. In the NRI ranking, EU countries occupy top positions (Poland – 37, Latvia – 39, Czech Republic – 30, Croatia – 44). Other neighbouring countries outstrip Ukraine (Turkey – 51, Russia – 48) or occupy positions similar to the Ukrainian one (Belarus – 61, Moldova – 66, Georgia – 68).

World Digital Competitiveness Ranking (WDCR) consists of three main components: Knowledge (assesses the capacity to understand and learn new technologies) (digital skills, abilities, research and development), Technology (assesses the economic conditions that enable

the development of digital innovations, including regulatory framework, access to capital, technological framework) and Future Readiness (assesses the preparedness of businesses, individuals, and the country for digital transformations, digital adaptability, mobility and e-participation).

In 2019, Ukraine ranked 60th among 63 countries included in the WDCR rating (it lost 2 positions compared to 2018, when it was 58th)⁹. Ukraine lags behind the EU countries, as well as other neighbouring countries (Turkey, Russia). Specifically, Ukraine received the highest result in the Knowledge component (40th spot among 63 countries), while in terms of Technology and Future Readiness it was at bottom (61st and 62nd position respectively).

This review of international digital development rankings shows that Ukraine lags behind EU countries, including the new EU Member States, most of which have a lower level of digital development than the EU average. In general, the pace of digital development of the new EU Member States has been more dynamic than that of Ukraine. Given the fact that within the framework of the creation of the EU's Digital Single Market¹⁰ these countries are implementing initiatives to digitize various sectors of their economy, the digital transformation of these countries is expected to accelerate, which will narrow the gap in the digital development between EU countries.

7) <https://networkreadinessindex.org/wp-content/uploads/2020/03/The-Network-Readiness-Index-2019-New-version-March-2020.pdf>

8) <https://networkreadinessindex.org/wp-content/uploads/2020/03/The-Network-Readiness-Index-2019-New-version-March-2020.pdf>

9) <https://www.imd.org/wcc/world-competitiveness-center-rankings/world-digital-competitiveness-rankings-2019/>

10) <https://ec.europa.eu/digital-single-market/en/digital-economy-and-society-index-desi>

Therefore, Ukraine also needs to accelerate its digital transformation to prevent further widening of the gap between our countries. Ukraine's weakest indicators, according to international indices and surveys, relate its unfavourable regulatory framework for digital innovation, as well as the fact that the country lags behind in the deployment of digital technologies and the development of telecommunications infrastructure. Hence, these issues need to be addressed in order to improve Ukraine's digital position in the region and the world.

Part 2. Methodology

This Part focuses on the methodological approach to estimating the effects of Ukraine's integration into the EU's Digital Single Market on international trade in services and goods of Ukraine, the productivity of Ukraine's economy and the welfare of Ukrainians and citizens of EU Member States.

This study is a quantitative assessment of the potential economic benefits of Ukraine's integration into the EU's DSM, which includes two main channels of influence – i. e. regulatory approximation in the digital sphere between Ukraine and the EU, which will reduce regulatory restrictions on digital trade between Ukraine and the EU, as well as acceleration of digital transformation in Ukraine.

In particular, it is expected that integration into the EU's DSM will expand access to EU online markets and advanced digital technologies, which will accelerate the development of the digital economy in Ukraine and will contribute to the gradual progress of Ukraine towards the European level of digital development. Digital transformation is defined as the introduction of “a fusion of advanced technologies that integrates physical and digital systems and when combined with innovative business models and processes, leads to the creation of smart products, services and significant improvement of productivity”¹. Digitalization is linked to general technological development and significantly accelerates it. As a result, digital transformation should have a positive impact on Ukraine's productivity and economic growth.

Regulatory approximation to EU digital law will help reduce regulatory barriers to cross-border digital trade between Ukraine and the EU through the use of common principles, standards and compatible systems in the digital sphere. This will help reduce the overall level of non-tariff barriers and trade costs in the trade in goods and services between Ukraine and the EU, as trade in goods and services is increasingly dependent on digital services that support trade transactions (e. g. electronic payments, electronic contracts, etc.)². As a result, the overall bilateral trade in goods and services between Ukraine and the EU, as well as the overall welfare of Ukraine and the EU, is expected to grow.

The key idea behind the calculations is that digital development (expressed in the Digitalization Index) has a positive effect on productivity and GDP growth. On the other hand, regulatory barriers and restrictions on digital trade (captured by the Digital Services Trade Restrictiveness Index) have a negative impact on overall trade in both goods and services. Estimation of the production function and gravity model of international trade makes it possible to quantify the effects of these two factors. Using these estimates, we develop integration scenarios and assess how accelerated digital development of Ukraine and reduced digital trade restrictions between Ukraine and the EU impact Ukraine's productivity and GDP, as well as trade and welfare of Ukraine and the EU.

Calculation of the Digitalization Index and the Digital Services Trade Restrictiveness Index

Composite Digitalization Index

In order to estimate the impact of digitalization, a Composite Digitalization Index was calculated for Ukraine, the EU and other countries included in the model. The index is calculated for 46 countries for the period from 2016 to 2018, it describes their digital development.

The structure of the Composite Digitalization Index corresponds to the structure of the Digital Economy and Society Index (DESI), which is calculated annually by the European Commission for EU Member States³. In particular, the Digitalization Index covers 5 components, each of which includes a set of indicators (a total of 11 – the choice of the indicators, inter alia, depended on the availability of the relevant data for Ukraine and the other 45 countries for the given period):

1) <https://eufordigital.eu/uk/digitising-industry-best-practices-to-promote-the-digital-transformation-of-smes-in-traditional-sectors-of-the-economy/>

2) https://www.oecd-ilibrary.org/trade/the-oecd-digital-services-trade-restrictiveness-index_16ed2d78-en

3) <https://ec.europa.eu/digital-single-market/en/desi>

- **Connectivity:**
 - Fixed broadband subscriptions
 - Technology Infrastructure Index
 - International internet bandwidth per internet user
 - Fixed broadband internet tariffs Households with Internet access.
- **Human capital/Digital Skills:**
 - Level of digital skills among population.
- **Use of Internet services by citizens:**
 - Percentage of people who use the internet at least once in 3 months.
 - Percentage of people aged 15+ who have made a digital payment in the past year.
- **Integration of digital technology by businesses:**
 - ICT use for business-to-business transactions. Business-to-consumer internet use.
- **Digital public services:**
 - Index of digital public services.

Table A1 (Annex A) shows how the composite Digitalization Index and its individual components were calculated, as well as sources of data for each indicator. All components were normalized from 0 to 1⁴.

The overall Digitalization Index is calculated for each country as the weighted average of the components⁵. According to the DESI methodology, they were weighted using the following weights: Connectivity (25%), Human capital/Digital Skills (25%), Use of Internet Services by Citizens (15%), Integration of Digital Technology by Businesses (20%) and Digital Public Services (15%).

Digital Services Trade Restrictiveness Index

To assess the impact of regulatory barriers on digital trade, we used the Digital Services Trade Restrictiveness Index (STRI). It quantifies the regulatory barriers that affect trade in digital services⁶. OECD calculates Digital STRI for 46 nations – OECD countries and some non-OECD countries⁷; Ukraine is not included in this index.

Trade in goods and services is increasingly dependent on digital services that support trade transactions (e. g. electronic payments, electronic contracts, etc.)⁸. Therefore, regulatory restrictions on cross-border trade in digital services negatively affect trade in goods and services in general. We used the Digital STRI as an approximation of the key regulatory restrictions for cross-border digital trade in goods and services.

For the purposes of this study, we used the already calculated Digital STRI for all countries for 2016-2018, while we estimated it for Ukraine using the OECD methodology. Our sample of countries for the model depended to a large extent on the OECD data concerning this index.

The index includes 5 components that cover different areas of regulatory policy and affect international trade in various services that enable digital trade. It is not an exhaustive list of all the barriers that affect digital trade, but it does make it possible to “focus on the most important restrictions”⁹.

In order to measure the Digital STRI for Ukraine, a survey of Ukrainian experts specializing in the areas covered by the index was conducted. Based on their answers, analysis of relevant legislation and estimates for other countries, generalized estimates for Ukraine were made (Table B1, Annex B).

Digital Services Trade Restrictiveness Heterogeneity Indices

For the purposes of the study, it is necessary to assess the differences in the regulatory framework that affects digital trade between

4) The lack of data limited the calculation of the dynamics of individual indicators during this period. Due to the lack of data for some indicators for individual years, the indicator for the following/preceding year was sometimes used or the method of linear interpolation for intermediate years was applied.

5) https://ec.europa.eu/information_society/newsroom/image/document/2018-20/desi-2018-methodology_E886EDCA-B32A-AEFB-07F5911DE975477B_52297.pdf

6) https://stats.oecd.org/Index.aspx?DataSetCode=STRI_H_IN-TRAEEA

7) China, Russia, Argentina, Brazil, India, Indonesia, Costa Rica, Saudi Arabia, and South Africa.

8) https://www.oecd-ilibrary.org/trade/the-oecd-digital-services-trade-restrictiveness-index_16ed2d78-en

9) <https://www.oecd-ilibrary.org/docserver/16ed2d78-en.pdf?expires=1599410884&id=id&accname=guest&checksum=B-19377F85336EBF8CC823AB4590F2FA6>

According to the OECD, the Digital STRI includes the following components*:

- **Infrastructure and connectivity.** This area covers measures related to communication infrastructures essential to engaging in digital trade. It maps the extent to which best practice regulations on interconnections among network operators are applied to ensure seamless communication; measures limiting or blocking the use of communications services, including Virtual Private Networks or leased lines; as well as measures on cross-border data flows and data localisation.
- **Electronic transactions.** This area covers issues such as conditions for issuing licenses for e-commerce activities, the possibility for online tax registration and declaration for non-resident firms, deviation from internationally accepted rules on electronic contracts, measures inhibiting the use of electronic signature, and the lack of effective dispute settlement mechanisms.
- **Payment systems and electronic payments.** This area captures measures that affect payments made through electronic means. It includes measures related to access to certain payment methods and assesses whether domestic security standards for payment transactions are adopted in line with international standards. Lastly, it also covers restrictions related to Internet.
- **Intellectual property rights.** This area covers domestic policies related to copyrights and trademarks that do not afford foreigners equal treatment with regard to IP protection. It also maps the existence of appropriate enforcement mechanisms to address infringements related to copyrights and trademarks, including those occurring online.
- **Other barriers affecting trade in digitally enabled services.** This area covers various other barriers to digital trade, including performance requirements affecting cross-border digital trade (e.g. mandatory use of local software and encryption or mandatory technology transfers); limitations on downloading and streaming; restrictions on online advertising; commercial or local presence requirements; and lack of effective redress mechanisms against anti-competitive practices online.

* <https://www.oecd-ilibrary.org/docserver/16ed2d78-en.pdf?expires=1599410884&id=id&accname=guest&-checksum=B19377F85336EBF8CC823AB4590F2FA6>

individual pairs of countries. Regulatory differences between countries increase the cost of complying with different regulatory requirements in cross-border digital transactions. Should Ukraine integrate into the EU's DSM, these regulatory differences are expected to decrease and approach the level of the EU countries within the DSM.

For this purpose, we used Digital Services Trade Restrictiveness Heterogeneity Indices (Digital STRI Heterogeneity Indices)¹⁰ which are also calculated by the OECD and reflect the differences between the two countries in terms of the regulatory framework affecting trade in digital services. Paired indices are based on the Digital STRI for the respective pair of countries.

For each country pair and for each indicator, it is determined whether the countries have the same requirements or not.

OECD calculates Digital STRI Heterogeneity Indices for OECD countries as well as individual non-OECD countries¹¹, and Ukraine is also not included in this index. Therefore, for our model, we used OECD data for all countries except Ukraine for the period of 2016-2018.

Paired Digital STRI Heterogeneity Indices between Ukraine and other countries were calculated based on a comparison of our estimated barriers to trade in digital services in Ukraine (Table B1, Annex B) and the corresponding indicators of other countries

10) https://stats.oecd.org/?datasetcode=STRI_DIGITAL

11) China, Russia, Argentina, Brazil, India, Indonesia, Costa Rica, Saudi Arabia, and South Africa.

(OECD data for other countries were obtained from the Digital Services Trade Restrictiveness Index Simulator¹²).¹³ Paired Heterogeneity Index_i^{UKR} between Ukraine and other countries was calculated as the sum of indicators C_j (weighted by W_j), for which Ukraine and another country j have different regulations¹⁴ (Formula 1). The higher the value of the index, the greater the regulatory disparities in digital trade between the countries.

(1)

$$\text{Heterogeneity Index}_i^{UKR} = \sum_{j=1}^c W_j * |C_j^i - C_j^{UKR}|$$

Designing Scenarios for Ukraine's Integration into the EU's DSM

Ukraine's integration into the EU's DSM involves:

- Regulatory approximation with EU law and standards in the digital sphere.
- Reducing regulatory restrictions on digital trade between the EU and Ukraine.
- Acceleration of the development of the digital economy in Ukraine due to the expansion of access to online markets and digital technologies in the EU.

To assess the potential effect of integration into the EU digital market, scenarios have been designed, each of which presents a set of indicators that characterize the level of reduction of the bilateral regulatory barriers to digital trade between Ukraine and the EU, as well as the level of digital development of Ukraine. In particular, it is assumed that regulatory differences in the digital sphere between the EU and Ukraine will decrease to the level of EU countries, and the level of digital development of Ukraine will gradually approach the EU average.

The digitalization scenarios are based on the Digitalization Index indicators for the new EU member states, which are closer in terms of

technological and economic development to Ukraine and have been members of the EU for a relatively short period. In particular, this group includes the countries of Central and Eastern Europe: Poland, Lithuania, Latvia, Estonia, Slovakia, the Czech Republic, Romania, Bulgaria, Croatia, and Slovenia.¹⁵

Further, for all these countries, the average Digitalization Index in 2018 was calculated – scenario (3) Table 2. Also, we identified three countries with the lowest (Bulgaria, Croatia, Romania) and three countries with the highest (Estonia, Lithuania, Slovenia) level of digitalization, and calculated the average values – scenarios (2) and (4), respectively. We considered these three possible digital development scenarios for Ukraine (1) as target levels that can be gradually achieved in the framework of its integration into the EU's DSM.

In designing scenarios for regulatory changes in digital trade, it is assumed that as a result of regulatory approximation with the EU, the level of regulatory differences between Ukraine and the EU will decrease from the current level of 0.245 (1) to the European level within the DSM (based on paired Digital STRI Heterogeneity Indices). In this context, three possible scenarios are considered: the average value of indices for the EU at 0.092 (3), the average value for EU countries with the largest heterogeneity with other EU countries¹⁶ – 0.142 (2) and the average value for EU countries with the smallest heterogeneity with other EU countries¹⁷ – 0.064 (4).

In addition, regulatory approximation with the EU will change the level of regulatory differences between Ukraine and other trading partners. That is, Ukraine will start applying the same rules to digital trade with other partners as the EU (these partners fall into groups – i. e. other OECD member countries¹⁸ and non-OECD countries¹⁹), this means that for Ukraine regulatory heterogeneity with other OECD members will decrease (from 0.286 to 0.182/0.145/0.127 depending on the scenario), and conversely, regulatory heterogeneity with non-OECD countries will increase (from 0.264 to 0.342/0.309/0.295 depending on the scenario).

It is important to note that the formation of the EU's DSM is underway and involves further regulatory harmonization between EU countries.

12) <https://sim.oecd.org/Simulator.ashx?lang=En&ds=DGSTR&d1c=dg&d2c=jpn>

13) To calculate paired indices between Ukraine and other countries, we used questionnaires of countries that were available in the Digital STRI Simulator for the last year, country questionnaires for previous years are not available. Therefore, we used the same country questionnaires when calculating the paired indices of Ukraine for the three years of 2016-2018.

14) We first found the difference between the weighted indicators of the two countries, then added the absolute values of these differences.

15) Hungary was not included in our sample due to the lack of data on some indicators of the Digitalization Index.

16) Austria, Germany, and the Czech Republic.

17) Luxembourg, Denmark, Lithuania.

18) Australia, Canada, Chile, Colombia, Israel, Japan, Mexico, New Zealand, Norway, Switzerland, Turkey, and the USA.

19) China, Russia, Brazil, India, Indonesia, Saudi Arabia, South Africa, and Ukraine.

Table 2. Scenarios of the impact of Ukraine's integration into the EU's DSM*

Indicator / Group of countries	Current level of Ukraine *	Scenarios**:		
		Bottom	Medium	Top
	(1)	(2)	(3)	(4)
Digitalization Index	0,564	0,596	0,663	0,719
Digital STRI Heterogeneity Index				
EU	0,245	0,142	0,092	0,064
Other OECD ***	0,286	0,182	0,145	0,127
Non-OECD ***	0,264	0,342	0,309	0,295

Notes:

* Data for the current level and scenarios for 2018.

** Scenarios: Average is calculated as the average value of 1) Digitalization Index for the new EU member states – Poland, Lithuania, Latvia, Estonia, Slovakia, the Czech Republic, Romania, Bulgaria, Croatia, and Slovenia 2) Digital STRI Heterogeneity Index for all EU countries. Bottom/Top level – the average value of 1) Digitalization Index for the three new EU member states with the lowest / highest values of the index 2) Digital STRI Heterogeneity Index for the three EU countries with the lowest / highest values of the index.

*** Digital STRI Heterogeneity Indices are calculated as average values of the paired indices of regulatory differences between the respective countries – Ukraine and EU countries, Ukraine and other OECD countries, Ukraine and non-OECD countries. Scenarios are calculated similarly for EU countries, i. e. Average heterogeneity between EU countries is at 0.092, between EU countries and other OECD members at 0.145, and between all EU countries and non-OECD countries at 0.309. Bottom/Top level is calculated in the same way, but as an average for the three EU countries with the lowest / highest index values. EU includes 22 member states included in the OECD Digital STRI. Other OECD countries include: Australia, Canada, Chile, Colombia, Israel, Japan, Mexico, New Zealand, Norway, Switzerland, Turkey, and the USA. Non-OECD include: China, Russia, Brazil, India, Indonesia, Saudi Arabia, and South Africa.

That is, regulatory heterogeneity between EU countries is expected to narrow. Ukraine's integration into the DSM will mean that Ukraine's regulatory framework will be closer to the current EU regulatory framework in the digital sphere. However, for the purposes of the study, we set the current level of regulation in the EU as a reference point for Ukraine.

Assessment of the Impact of Digitalization on the Productivity and Economic Growth of Ukraine

The assessment of the impact of increased digitalization of Ukraine on the productivity of Ukraine's economy is based on the Cobb-Douglas production function. According to the applied model, each country produces a unique product using factors of production (labour and capital) and certain technologies that differ depending on the country. Given the existing capital stock K , labour L , the supply of which is inelastic, and productivity A , commodity i is produced according to the following production function:

(2)

$$Q_{it} = A_{it} K_{it}^{\alpha_K} L_{it}^{\alpha_L}$$

Technical modernization through the introduction of new digital skills and production processes is measured as a function of digital development. We assume a log-linear relationship between digitalization and productivity .

(3)

$$\ln A_{it} = a_{0i} + a_1 f(\text{Digitalization}_{it})$$

Digitalization is a composite index of digitalization that summarizes the relevant digital indicators in various sectors of economy and society and tracks the digital development of Ukraine and other countries (for description of the Digitalization Index see p. 14-15). In

addition, there is a country-specific productivity component, a_{0i} , due to variations in human capital, institutions and other factors that vary from country to country but either do not change or change very slowly over time (therefore assumed to be constant).

Combining (2) and (3), we obtain an econometric specification to assess the impact of digitalization on productivity and GDP (4). We assess specification (4) using a fixed effects model.

We expect the impact to be positive: a 1% increase in digitalization will increase GDP by a_1 %.

(4)

$$\ln Q_{it} = a_{0i} + a_1 \text{Digitalization}_{it} + \alpha_k \ln K_{it} + \alpha_L \ln L_{it} + \epsilon_{it}$$

Digitalization increases productivity directly – by better organizing the processes of resource use, as well as indirectly – by encouraging the introduction and development of modern technologies. Our index takes into account these technological changes. However, it may also take into account technological changes caused by other factors that are positively correlated with digitalization. To solve this problem, we added fixed effects for countries, as well as the variable of “human capital”, but other factors may also contribute to the overall effect on productivity and GDP.

Annex E provides a detailed description of the model and general estimated results.

Assessment of the Impact on International Trade in Goods and Services

The key estimation tool is the gravity model of international trade – a recognized method of econometric analysis of foreign trade. The gravity model links global trends in production and consumption with global trade trends. The popularity of the model is due to several factors:

- This is a global trade general equilibrium model. General equilibrium models capture not only the direct impact of economic and political changes on trade between two countries, but also how it affects other countries. For example, when China imposed high tariffs on soybeans imported from the United States, it resulted in increased soybean exports from Brazil to China.

- This model is consistent with long-standing and modern theories of international trade: Ricardo’s model of comparative advantage, Krugman’s model of monopolistic competition, and Melitz’s model of firm heterogeneity in global markets.

- Most importantly, it is the most empirically successful quantitative economic model due to its high explanatory power: the high R-square in the regression of the export logarithm on the exporter’s GDP, the importer’s GDP and the distance is about 0.6-0.7. In the analysis of panel data with a full set of fixed effects, the R-square is even higher – about 0.9.

When evaluating the model, all specific factors for each country and each pair of countries are taken into account. The remaining difference (undertrading) is a deviation from global trade trends that cannot be explained by the exporter’s production capacity, importer’s market size, specific trade cost factors such as distance, cultural differences, free trade agreements, import duties, etc. (for more details on the method, see Annex C. Gravity Model).

Like any other method, the gravity model of international trade has certain limitations. The method estimates trade taking into account long-term trends, is static and is based on the assumption of full employment. Accordingly, it does not take into account structural dynamic changes and cannot be used to explain short-term fluctuations.

The study used the following specification of the model for exports of goods and services in 2016–2018 (For detailed specification, see Annex C. Formula 3):

- Dependent variable – the total export flow of goods and services from country i to country j (all possible pairs of countries).
- Independent variables – distance between countries and common characteristics (borders, language, law), existence of a free trade agreement, level of tariff protection (for goods), level of regulatory heterogeneity in the digital sphere between the two countries, and a set of fixed effects for each country.

We use a structural gravity model to measure changes in trade flows and welfare caused by regulatory approximation between Ukraine and the EU in the digital sphere and the growing level of digitalization of Ukraine’s economy. This model was previously used to measure the effect of the North American Free Trade Agreement (NAFTA)

(Anderson et al. 2015), the Transatlantic Trade and Investment Partnership (TTIP) (Felbermayr et al., 2015), and Brexit (Jackson and Shepotylo, 2018).

A detailed specification is provided in Annex D and makes it possible to estimate multilateral resistance to export and import (5-6):

(5, 6)

$$\Omega_i^{1-\sigma} = \sum_j \frac{E_j}{Y_w} \left(\frac{\tau_{ij}}{P_j} \right)^{1-\sigma}$$

$$P_j^{1-\sigma} = \sum_i \frac{Y_i}{Y_w} \left(\frac{\tau_{ij}}{\Omega_i} \right)^{1-\sigma}.$$

Multilateral export resistance is the weighted average cost of all bilateral trade costs for producers of goods in each country – as if every country i supplies its products to the single world market. Similarly, multilateral import resistance is the weighted average of all bilateral trade costs borne by consumers in each region. It is as if each country j buys goods from the single world market.

Therefore, the modelling process consists of the following stages:

- Estimation of gravity models for exports of goods and services with the current level of digitalization of Ukraine and the level of regulatory heterogeneity in the digital sphere between Ukraine and other countries over the medium term (2016-2018):
 - obtaining values of the coefficients of influence of independent variables on the dependent ones (Formula 2. Annex C). Annex F presents the general results of the assessment of gravity models for goods and services and the values of the coefficients.
- Estimation of the gravity model for exports of goods and services for the latest available period (2018) with the changed level of digitalization of Ukraine and the level of regulatory heterogeneity in the digital sphere between Ukraine and other countries, as well as fixed coefficients of influence of independent variables on the dependent one:
 - calculation of potential levels of exports of goods and services from Ukraine to the EU and from the EU to Ukraine according to the given scenarios of changes in the

level of regulatory heterogeneity in the digital sphere between Ukraine and other countries (Formula 3. Annex C)

- taking into account the change in the level of digitalization of Ukraine's economy in the given scenarios of change using assessment of the impact of digitalization on the productivity and economic growth of Ukraine (Formula 4. Annex C)
- Calculation of the level of change in exports of goods and services due to the potential reduction of regulatory heterogeneity in the digital sphere between Ukraine and the EU and the growth of the overall level of digitalization of Ukraine's economy – as the difference between real and potential trade (Formula 5. Annex C)

Because of limitations in the available data, the developed model is based on the assessment of 42 countries (including 22 EU countries).

Assessment of the Welfare Effects

In our model, the change in welfare occurs due to changes in the prices of consumer goods P to P' . Prices will go down due to reduced barriers to trade and increased productivity as a result of development of the digital economy, reduction of digital barriers and the elimination of regulatory differences. Also, prices will decrease due to increased incomes from Y to Y' as a result of increased productivity and changing trade flows.

The structural gravity model allows us to estimate consumer price indices, which are related to internal multilateral resistance, for the baseline scenario:

(7)

$$P_i^{1-\sigma} = \sum_j \frac{Y_j}{Y_w} \left(\frac{\tau_{ij}}{\Omega_j} \right)^{1-\sigma}$$

For the hypothetical scenario:

(8)

$$P'_i{}^{1-\sigma} = \sum_j \frac{Y'_j}{Y_w} \left(\frac{\tau'_{ij}}{\Omega_j} \right)^{1-\sigma}$$

Changes in welfare are calculated as:

(9)

$$\hat{W} = 100\% \times \left(\frac{\hat{Y}_i'}{\hat{P}_i} - 1 \right)$$

The total change in welfare is calculated as the weighted average change in welfare from trade in goods and services. The shares of industry/agriculture and services in the GDP of the respective country are used as weights.

For more details on the welfare impact assessment methodology, see Annex D.

Data Description

Data on bilateral trade in goods in billions of USD at current prices are sourced from the UN COMTRADE database²⁰, and those on trade in services from the WTO-UNCTAD annual trade in services database²¹.

Data on gross domestic product (GDP) in USD at current prices and population are drawn from the World Development Indicators (WDI) published by the World Bank.²²

Data on free trade agreements, geographical/cultural characteristics and distance between countries are taken from the Center D'Études Prospectives et D'Informations Internationales Gravity dataset (CEPII, for a detailed description of the data, see Head et al., 2010)²³.

Import duty rates for countries (Effectively Applied AHS) are drawn from the UNCTAD Trade Analysis Information System (TRAINS) database²⁴.

The sources of data for the composite Digitalization Index are presented in Table A1 (Annex A).

Data for the Digital STRI and Digital STRI Heterogeneity Indices are sourced from the OECD Database.²⁵

20) <https://comtrade.un.org/>

21) http://data.wto.org/assets/UserGuide/services_annual_dataset.zip Statistics on trade in commercial services are sourced from the IMF Balance of Payments Statistics and from the Trade in Services by Partner Country dataset of the OECD. Data for European Union members, EU candidate and EU observer countries are drawn from Eurostat. For some economies, data are drawn from national sources. Where possible, reported data are complemented by estimations produced by the WTO and UNCTAD.

22) World Development Indicators

23) CEPII, http://www.cepii.fr/cepii/en/bdd_modele/bdd.asp

24) <https://unctad.org/en/Pages/DITC/Trade-Analysis/Non-Tariff-Measures/NTMs-trains.aspx>

25) https://stats.oecd.org/Index.aspx?DataSetCode=STRI_DIGITAL#

Part 3. Empirical Results

This Part presents estimates of the expected economic effects of Ukraine's integration into the EU's DSM. In particular, it elaborates on estimates of the impact of the growing level of economy digitalization on Ukraine's economic growth, as well as the effects of regulatory approximation in the digital sphere between Ukraine and the EU on the intensification of trade in goods and services between Ukraine and the EU and the welfare of Ukrainian and EU citizens.

Calculated index values

Digitalization Index

The calculated Digitalization Index values for Ukraine and other countries in 2018 are presented in Figure A1 (Annex A). Ukraine is at the bottom of the ranking (41st among 46 countries based on 2018 indicators¹). Sweden, the Netherlands, the United States, Denmark, and the United Kingdom are the most high-ranking countries, demonstrating the highest level of digital development among the nations under consideration.

The level of digital development in Ukraine (0.56 in 2018) is far below that of the leading EU countries (Sweden – 0.81, the Netherlands – 0.81, Denmark – 0.80) and the EU average (0.71) (Figure 1). Ukraine also lags behind the new EU member states, which have a lower level of economic development compared to the other EU Member States (the average value of the index for them is 0.66). The leaders among the new EU members are Estonia, Lithuania, and Slovenia (with the average index value at 0.72), while the lowest level of digitalization in the EU is demonstrated by Bulgaria, Croatia, and Romania (with the average value of the index at 0.60).

The dynamics of the Digitalization Index in 2016-2018 indicates a widening in the gap between Ukraine and the EU over this period (Figure 3). In particular, the digitalization of the neighbouring EU countries has grown faster than that of Ukraine. As a result, Ukraine has lost traction even compared to the EU countries with the lowest the Digitalization Index (Croatia, Bulgaria, and Romania).

A detailed comparison of the individual components and indicators of the Digitalization

Index for Ukraine and EU countries is presented in Table A2 (Annex A). In particular, as of 2018, the most significant components within the structure of the Digitalization Index of Ukraine were Human Capital (the level of digital skills among the population) and Integration of Digital Technology by Businesses (use of ICT in business-to-consumer interactions and business transactions). The widest gap with the EU countries has been found in: Digital Public Services, Connectivity (in particular, fixed broadband internet access and household access to the internet, etc.) and Use of Internet by citizens (in particular, the share of internet users and the share of individuals who have made digital payments). At the same time, Ukraine was ahead of the EU countries (including the new member states) in terms of the affordability of internet use.

The calculated values of the Digitalization Index generally correspond to the international rankings of the countries' digital development. In particular, the correlation coefficient between our index and the DESI for EU countries was 89% in 2018.

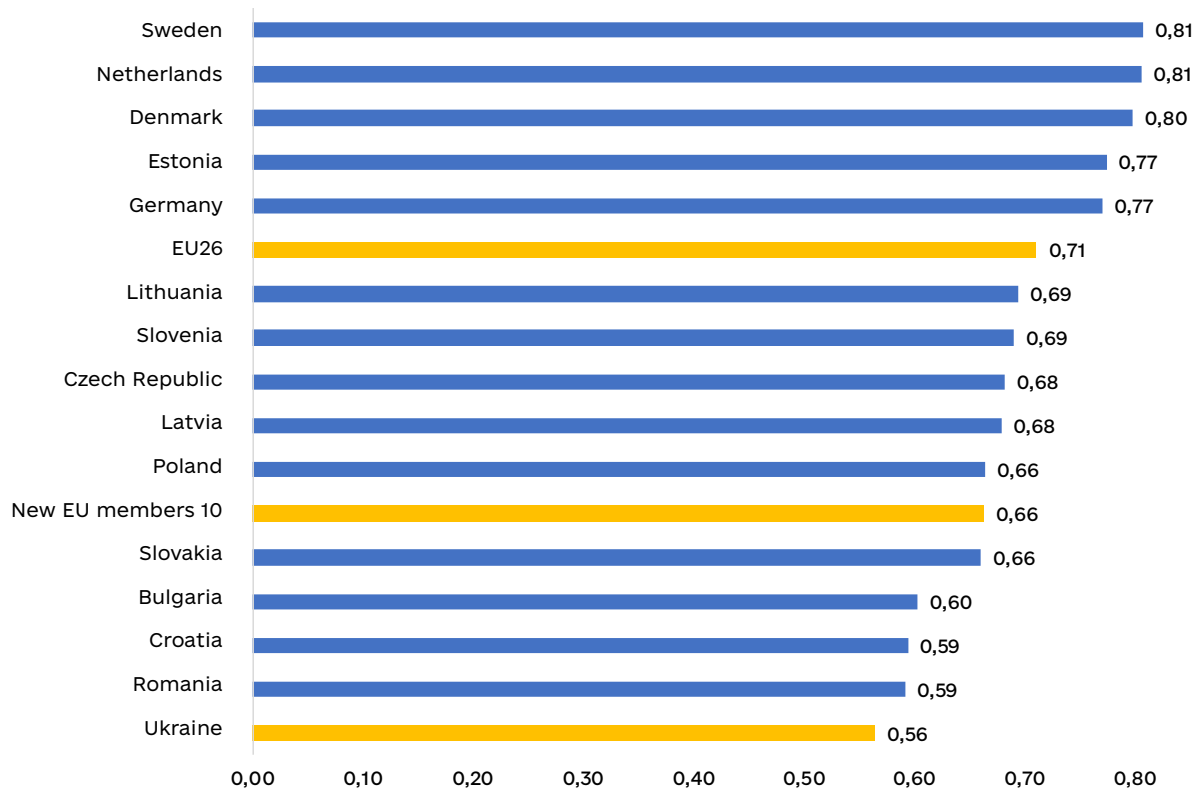
Digital STRI

Consolidated results of the survey of experts and analysis of the regulatory framework to estimate the Digital STRI for Ukraine in 2016-2018:

"Infrastructure and Connectivity" does not contain a significant number of regulatory barriers to cross-border digital trade in Ukraine. The requirement regarding the interconnection of telecommunication networks is established by law². When providing internet access services, operators ensure the interconnection of telecommunications networks on a contractual

1) This is also due to the fact that most of the countries in our sample are OECD member countries with a high level of economic development.

2) <https://zakon.rada.gov.ua/laws/show/1280-15#Text>

Figure 2. Comparison of the Digitalization Index of Ukraine and EU countries, 2018

Source: own calculations.

basis³. In both market segments for the services of fixed⁴ and mobile⁵ internet, the regulator has identified telecommunications operators with a significant market power, upon which the law imposes regulatory obligations to ensure competition (including with regard to prices and conditions of interconnection, as well as making public interconnection reference offers). The experts pointed to some problematic issues associated with ensuring economic competition in these markets, as well as the method of determining the presence of operators with significant market power, and so on. However, these factors are not viewed as significant barriers in Ukraine.

Regarding cross-border data flows in Ukraine two restrictions have been introduced to ensure the protection and security of personal data: certain types of data must be stored locally, and data transfer is only possible to countries that

provide an adequate level of protection or certain safeguards.

“Electronic Transactions”: one of the major barriers is the disparity between the national requirements for foreign economic agreements (contracts), in particular electronic ones, and international practices and standards. In addition, online registration and declaration of tax are not available to non-resident companies.

Key electronic authentication measures, such as electronic signature recognition, are being introduced in Ukraine. Positive changes in this area took place after the adoption in 2017 of the European integration law of Ukraine “On Electronic Trust Services”⁶, which aligned the legislation in the field of electronic digital signatures with European rules; as well as the Law of Ukraine “On Amendments to Certain Laws of Ukraine with regard to Eliminating

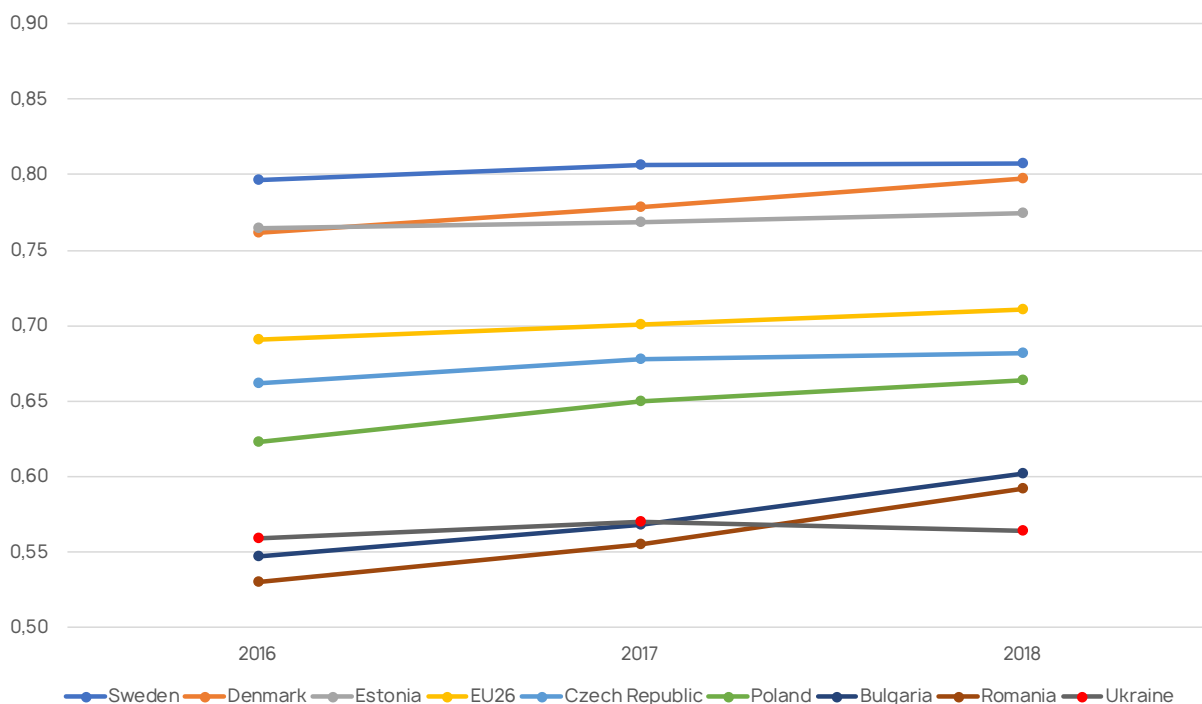
3) Decision No. 541 of the National Commission for the State Regulation of Communications and Informatization dated 19.11.19.

4) PJSC Ukrtelecom on the market of traffic transit services in the fixed public telephone network: <https://nkrzi.gov.ua/index.php?r=site/index&pg=444&id=8967&language=uk>

5) Each telecommunications operator operating in the market of traffic termination services within mobile networks is described as a telecommunications operator with a significant market power in the market of traffic termination services: <https://nkrzi.gov.ua/index.php?r=site/index&pg=422&id=8767&language=uk>

6) Law of Ukraine No. 2155-VIII “On Electronic Trust Services” of 05.10.2017 <https://zakon.rada.gov.ua/laws/show/2155-19#Text>

Figure 3. Dynamics of the Digitalization Index for Ukraine and EU countries in 2016-2018



Source: own calculations

Administrative Barriers to the Export of Services”⁷, which made it possible for Ukrainian businesses to conclude foreign economic agreements (FEA) in electronic form. However, problems have arisen with the enforcement of these legal requirements due to the lack of practical mechanisms for the use of electronic digital signatures in foreign economic contracts.⁸ In addition, there is a lack of mutual recognition of electronic identification and electronic trust services for cross-border electronic transactions between Ukraine and major trading partners, in particular EU countries (the relevant procedure for mutual recognition was approved in 2019⁹).

“Measures related to payment systems and electronic payments” are identified as a significant barrier to cross-border digital trade in Ukraine during the reporting period. Cross-border money transfers and electronic payment services, as well as internet banking were limited due to strict currency regulation¹⁰. However, the National Bank has been gradually easing currency

regulation restrictions¹¹. Approaches to regulation in the field of payment systems and funds transfer do not meet European and international standards¹² and need to be comprehensively reviewed and updated in order to expand the list of payment services that can be provided in Ukraine, to promote the development of the internal market of non-bank payment systems, and to ensure interaction with international payment systems¹³. Another significant problem is the high cost and low speed of cross-border transfers. In addition, national payment security standards differ from international standards.

“Intellectual Property Rights Policy” also contained restrictions. Experts pointed to the lack of effectiveness and efficiency of the respective legal requirements, as well as judicial and administrative measures regarding the protection of copyright and related rights on the internet. The legal framework for the protection of copyright and related rights on the Internet requires significant amending¹⁴. Ukraine remains on the Priority Watch List

7) Law of Ukraine No. 1724-VIII “On Amendments to Certain Laws of Ukraine with regard to Eliminating Administrative Barriers to Export of Services” of 03.11.2016 <https://zakon.rada.gov.ua/laws/show/1724-19#Text>

8) <https://news.dtki.ua/state/zed/46125>

9) <https://zakon.rada.gov.ua/laws/show/60-2019-%D0%BF#Text>

10) <https://www.contactukraine.com/banking/current-currency-control-regulations>

11) <https://www.pwc.com/ua/en/publications/assets/tax-newsletter/2018/pwc-newsletter-currency-control.pdf>

12) In particular, Directive (EU) 2015/2366 and Directive 2009/110/EC.

13) http://w1.c1.rada.gov.ua/pls/zweb2/webproc4_1?pf3511=70412

14) <https://www.me.gov.ua/Documents/Detail?title=ProktZakonu-UkrainiproAvtorskePravoIsumizhniPrava>

Table 3. Estimation of Ukraine's Digital STRI in 2016-2018.

	2016	2017	2018
Infrastructure and connectivity	0.08	0.08	0.08
Electronic transactions	0.06	0.04	0.04
Payment systems and electronic payments	0.06	0.06	0.06
Intellectual property rights	0.06	0.04	0.04
Other barriers affecting trade in digital services	0.04	0.04	0.04
Overall Digital STRI	0.31	0.26	0.26

Source: own calculations.

based on the Special 301 report of the US Trade Representation focusing on the worldwide protection of intellectual property rights, including due to “failure to implement an effective means to combat widespread online copyright infringement”¹⁵. There were problems with ensuring proper protection of trademarks, certain discriminatory provisions were applied to foreign companies (different amount of state duty for the registration of a trademark certificate¹⁶, different requirements for the trademark registration procedure for non-residents).

At the same time, experts mentioned some positive recent measures to reform this area in line with European and international standards. A specialized intellectual property court was established, and temporary measures to protect intellectual property rights on the internet became available. In particular, this concerns the Law of Ukraine “On State Support for Cinematography in Ukraine”, which contains provisions requiring to remove pirated content that is posted online upon a request by the copyright holder, etc.

“Other barriers affecting trade in digital services” include technical requirements concerning the use of local software and cryptography¹⁷, as well as other restrictions – i. e. problems with the recognition of electronic primary foreign economic documents by the fiscal authorities of Ukraine, etc. At the same time, Ukraine has not applied restrictions on downloads and streaming, restrictions on online advertising and has not required commercial or local presence for digital cross-border transactions. The law also establishes the rule that companies are entitled to compensation when business practices

restrict competition in this market (however, it was noted that compensation to companies for anti-competitive actions on the internet is uncommon¹⁸).

Table 3 includes the results of calculations of the total value and individual components of the Digital STRI for Ukraine in 2016-2018. In 2017-2018, the overall index decreased due to the reduction of restrictions related to electronic transactions and intellectual property rights.

According to our estimates, the overall level of restrictions on trade in digital services in Ukraine significantly exceeds the average level of barriers between the EU and OECD countries in 2016-2018. Regulatory barriers in Ukraine are higher compared to various EU countries. Countries with the lowest restrictions on trade in digital services in the EU are Estonia, Luxembourg, and Slovakia (Figure 4).

For Ukraine, the most significant restrictions are found in areas such as electronic payments and settlements, electronic transactions, protection of intellectual property rights on the internet, and other barriers affecting trade in digital services (Figure 5).

Countries' Digital STRI Heterogeneity Indices

Based on OECD data on Digital STRI Heterogeneity Indices, we calculated the average level of the regulatory heterogeneity between EU countries¹⁹, EU countries and other OECD member countries²⁰, and EU countries and non-

15) https://ustr.gov/sites/default/files/2020_Special_301_Report.pdf

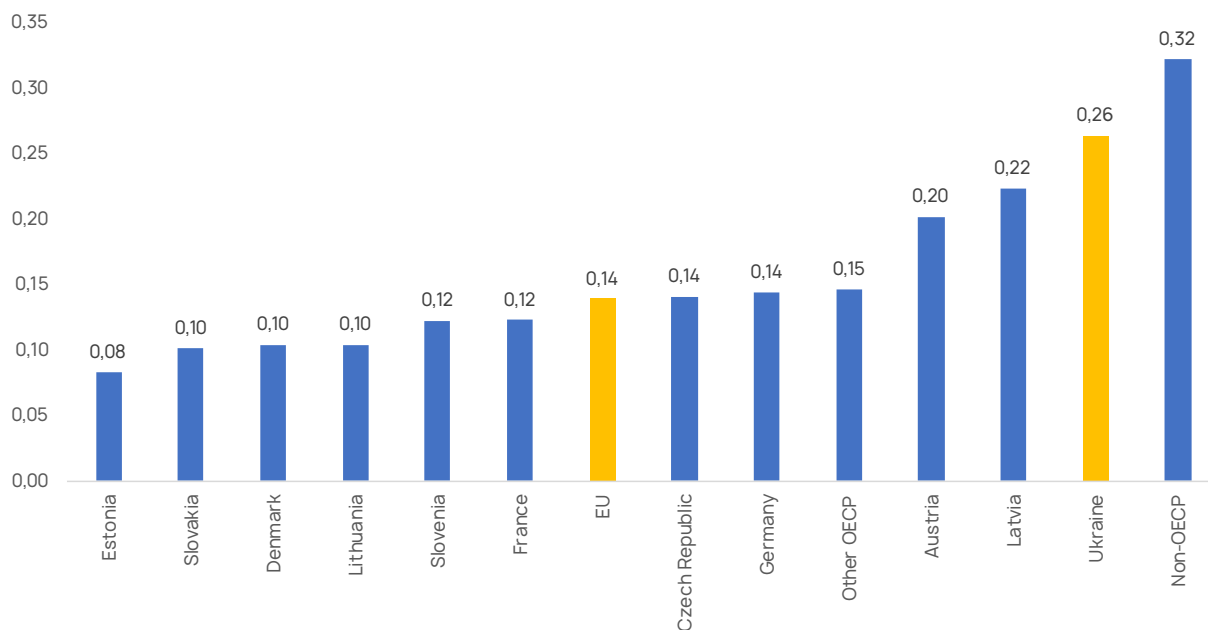
16) Law No. 1977-VIII “On State Support for Cinematography in Ukraine” of March 23, 2017 <https://zakon.rada.gov.ua/laws/show/1977-19#Text>

17) See, for example, https://ips.ligazakon.net/document/view/DPA0305?an=26&ed=2010_07_12

18) <https://yur-gazeta.com/publications/practice/antimonopolne-konkurentne-pravo/vidshkoduвання-zbitkiv-za-porushennya-konkurenciyi-nacionalni-ta-svitovi-tendenciyi-private-enforce.html>

19) A total of 22 EU countries included in the OECD Digital STRI Index.

20) Australia, Canada, Chile, Colombia, Israel, Japan, Mexico, New Zealand, Norway, Switzerland, Turkey, and the USA.

Figure 4. Digital STRI by countries*, 2018

Source: for Ukraine – own calculations, for other countries – OECD Digital STRI.

Note: *Other OECD countries include: Australia, Canada, Chile, Colombia, Israel, Japan, Mexico, New Zealand, Norway, Switzerland, Turkey, and the United States. Non-OECD countries include: China, Russia, Brazil, India, Indonesia, Saudi Arabia, and South Africa.

OECD countries²¹. The average index of regulatory heterogeneity in the digital sphere between EU countries is much lower than between EU and non-OECD countries. According to our estimates, Ukraine's heterogeneity with EU countries is also much higher than that of EU countries among themselves (Figure 6).

Assessment of the Impact of Digitalization on Productivity and Economic Growth of Ukraine

Increased digitalization of Ukrainian economy will have a positive effect on its productivity and economic growth – depending on the level of digitalization, the positive impact on Ukraine's GDP can range from 2.4 to 12.1% (Figure 7). According to our estimates, a 1% increase in digitalization will entail a 0.42% increase in Ukraine's GDP (Annex D). Accordingly, by raising the digitalization of its economy from the current level (0.5644) to the lower level of the new EU Member States (0.6) Ukraine will attain an additional GDP growth of 2.4% (USD 3.1 billion).

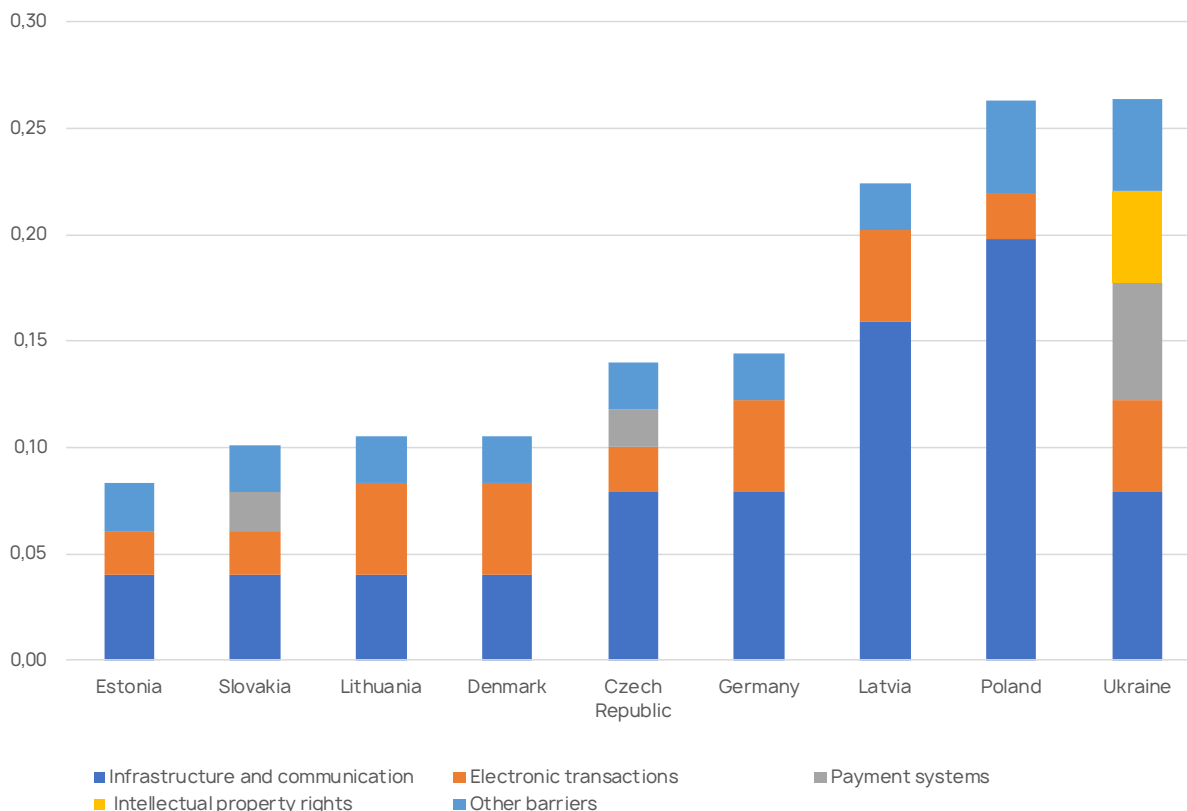
Should it achieve the medium and top level of digitalization of the new EU Member States (0.66 and 0.72, respectively), the additional effect on Ukraine's economy may produce a 7.5 and 12.1% GDP growth, respectively (USD 9.8 and 15.8 billion). These results attest to the role of digital technology in the overall technological development of nations in the modern world.

Assessment of the Impact on Bilateral Trade in Goods and Services between Ukraine and the EU

According to our estimates, exports of services from Ukraine to EU countries may increase by 7.6-12.2% due to approximation of Ukraine's regulatory framework and level of digitalization to those of the EU as a result of Ukraine's integration into the EU's DSM (Figure 8). In 2018, the volume of exports of services from Ukraine to the EU amounted to about USD 4 billion²². Provided that regulatory approximation reduces the restrictions on digital trade between Ukraine and the EU from the current level (0.245) to the lower level of the EU Member States

21) China, Russia, Brazil, India, Indonesia, Saudi Arabia, and South Africa.

22) According to the State Statistics Service of Ukraine.

Figure 5. Structure of the Digital STRI for Ukraine and EU countries, 2018

Source: for Ukraine – own calculations, for other countries – OECD Digital STRI.

(0.142) and Ukraine increases the digitalization of its economy (from 0.564 to 0.596), exports of services to the EU are expected to increase by USD 302.5 million or 7.6% (Table F2 presents the results of the assessment for individual countries).

Therefore, under the scenario that implies achieving medium and top levels of regulatory approximation with the EU (0.092 and 0.064, respectively) and increasing the digitalization of the economy (to 0.663 and 0.719, respectively), additional growth in exports of services to the EU may amount to USD 394 and 485.5 million, respectively (9% and 12.2%).

Moreover, exports of services from EU countries to Ukraine are expected to increase by USD 191, 252 and 305 million, respectively (5.7%, 7.5% and 9.1%).²³

Ukraine's integration into the EU's DSM may increase exports of goods from Ukraine to EU countries by 11.8-17% (Figure 9). In 2018, exports of goods from Ukraine to the EU amounted to

about USD 20 billion²⁴. If regulatory heterogeneity between Ukraine and the EU decreases from the current level (0.245) to the lower level of the EU Member States (0.142), and the digitalization of its economy accelerates (from 0.564 to 0.596), it will increase its exports of goods to the EU by USD 2.4 billion or 11.8% (Table F3 presents the estimates for individual countries).

Therefore, under the scenario that implies achieving medium and top levels of regulatory approximation with the EU (0.092 and 0.064, respectively) and increasing the digitalization of the economy (to 0.663 and 0.719, respectively), additional growth in exports of goods to the EU could reach USD 2.9 and 3.4 billion, respectively (14.4% and 17%).

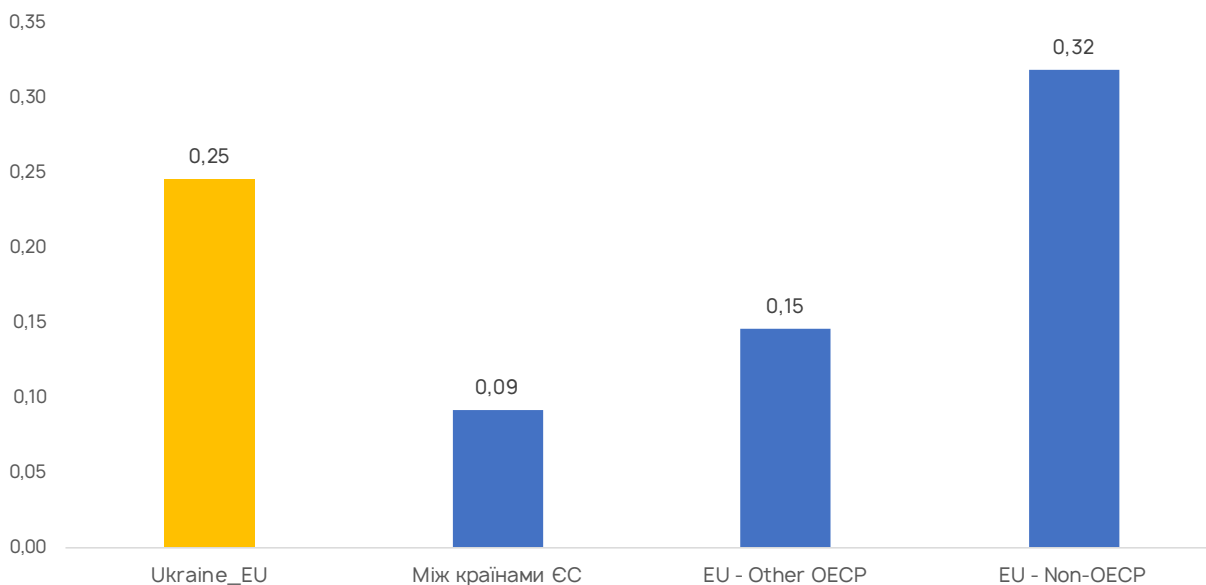
In addition, exports of goods from EU countries to Ukraine are expected to increase by USD 4.1, 4.6 and 5.0 billion, respectively (17.7%, 19.8% and 21.7%)²⁵.

23) Of the volume of exports of services from the EU to Ukraine in 2018 according to the State Statistics Service of Ukraine.

24) According to the State Statistics Service of Ukraine.

25) Of the volume of exports of goods from the EU to Ukraine in 2018 according to the State Statistics Service of Ukraine.

Figure 6. Average Digital STRI Heterogeneity Indices* between EU countries and other countries, 2018

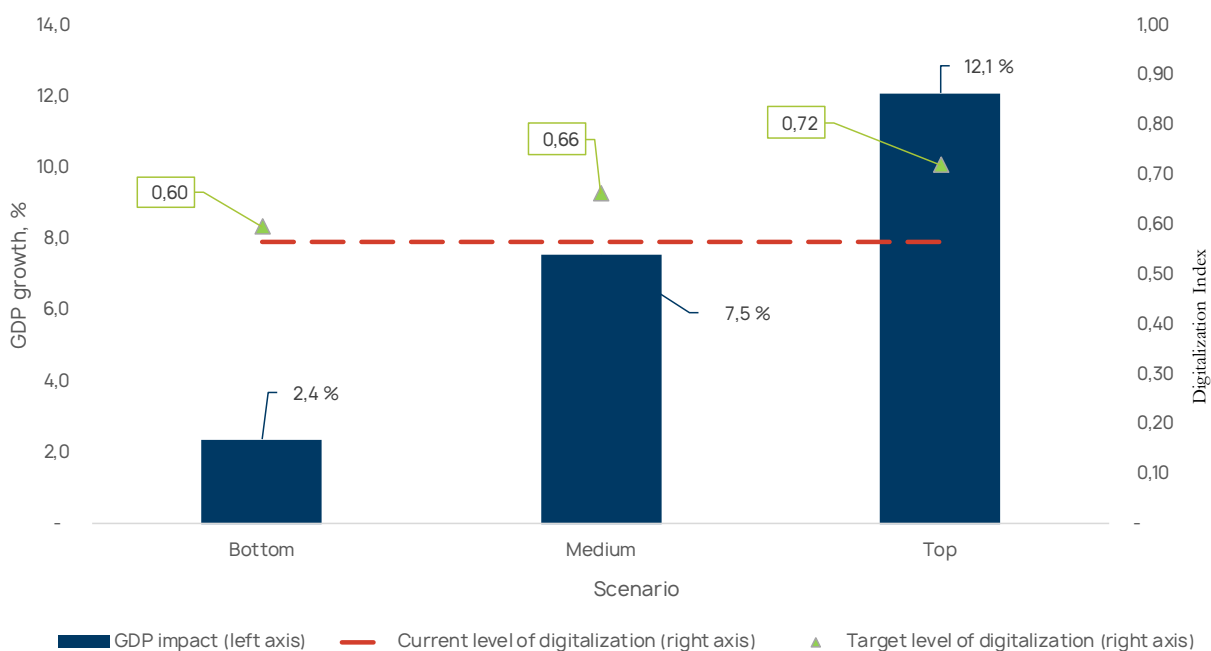


Source: for Ukraine – own calculations, for other countries – average values of paired indices of the OECD Digital STRI Heterogeneity Indices.

Notes: *Average values of paired Digital STRI Heterogeneity Indices between countries regarding trade in digital services.

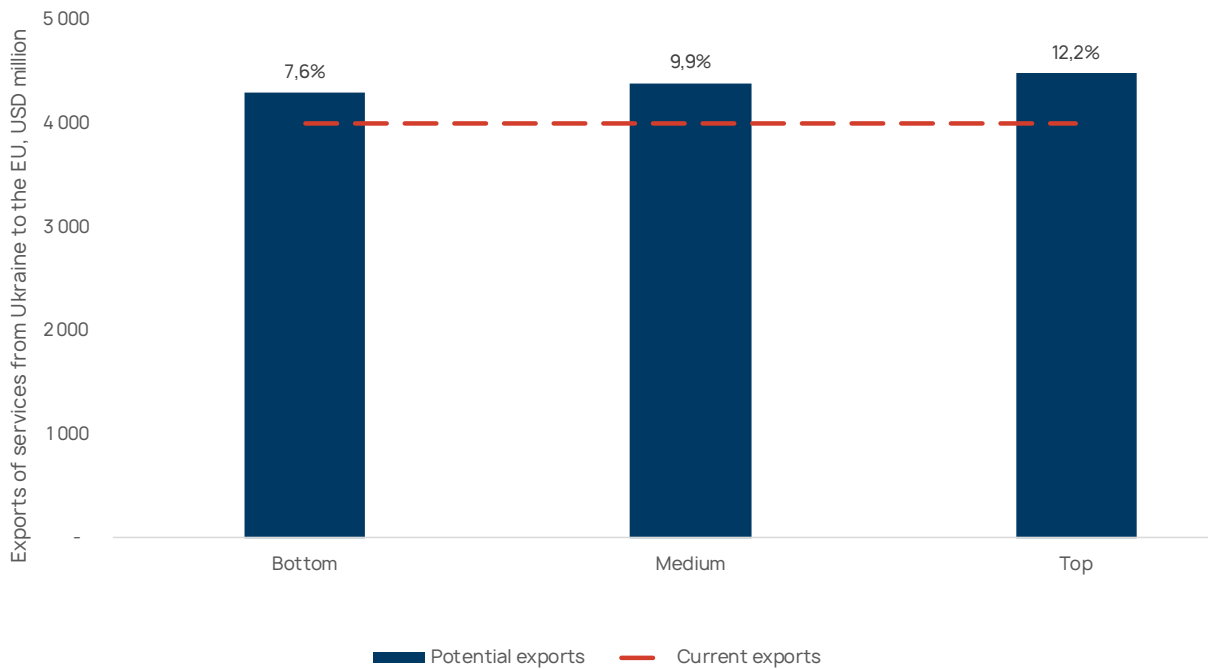
**Other OECD countries include: Australia, Canada, Chile, Colombia, Israel, Japan, Mexico, New Zealand, Norway, Switzerland, Turkey, and the United States. Non-OECD countries include: China, Russia, Brazil, India, Indonesia, Saudi Arabia, and South Africa.

Figure 7. Impact of digitalization on Ukraine's GDP growth: three digitalization increase scenarios



Source: own calculations. The left axis – GDP growth (%), the right axis – the level of digitalization. The current level of digitalization of Ukraine as of 2018.

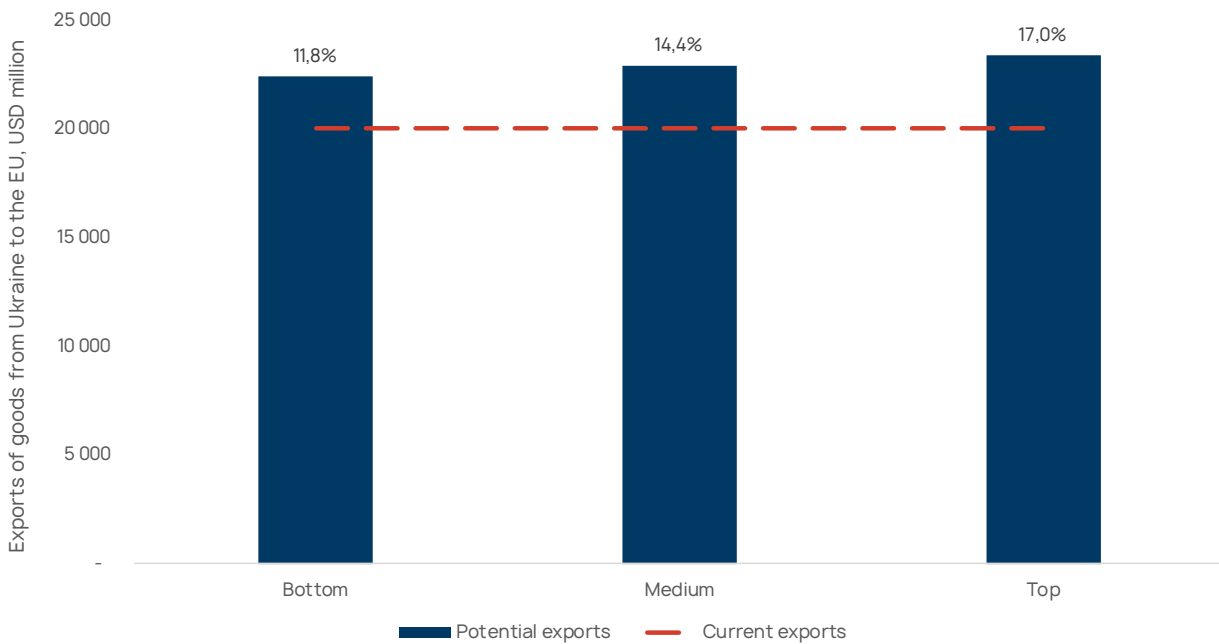
Figure 8. The impact of Ukraine's integration into the EU's DSM on the exports of services from Ukraine to the EU*: three integration scenarios



Source: own calculations. The current level of Ukraine's exports of services to the EU – as of 2018

Note: *Based on data estimates for 42 countries (including 22 EU countries) due to limitations in available data. All the above estimates of changes in exports are calculated for 28 EU countries by extrapolating the results obtained for 22 EU countries.

Figure 9. The impact of Ukraine's integration into the EU's DSM on exports of goods from Ukraine to the EU*: three integration scenarios



Source: own calculations. The current level of exports of Ukrainian goods to the EU as of 2018

Note: *Based on data estimates for 42 countries (including 22 EU countries) due to limitations in available data. All the above estimates of changes in exports are calculated for 28 EU countries by extrapolating the results obtained for 22 EU countries.

According to the estimation results, the positive effect of reducing regulatory digital barriers may be more pronounced for trade in goods between Ukraine and the EU, which can be due to the fact that digital barriers to trade in goods are more restrictive than to trade in services.

It is expected that the reduction of barriers to digital trade between Ukraine and the EU as a result of integration into the EU's DSM will help reduce the overall level of non-tariff barriers and trade costs in the bilateral trade in goods and services between Ukraine and the EU (through digitalization of trade transactions and public services, etc.).

Assessment of the Welfare effects for Ukraine and the EU

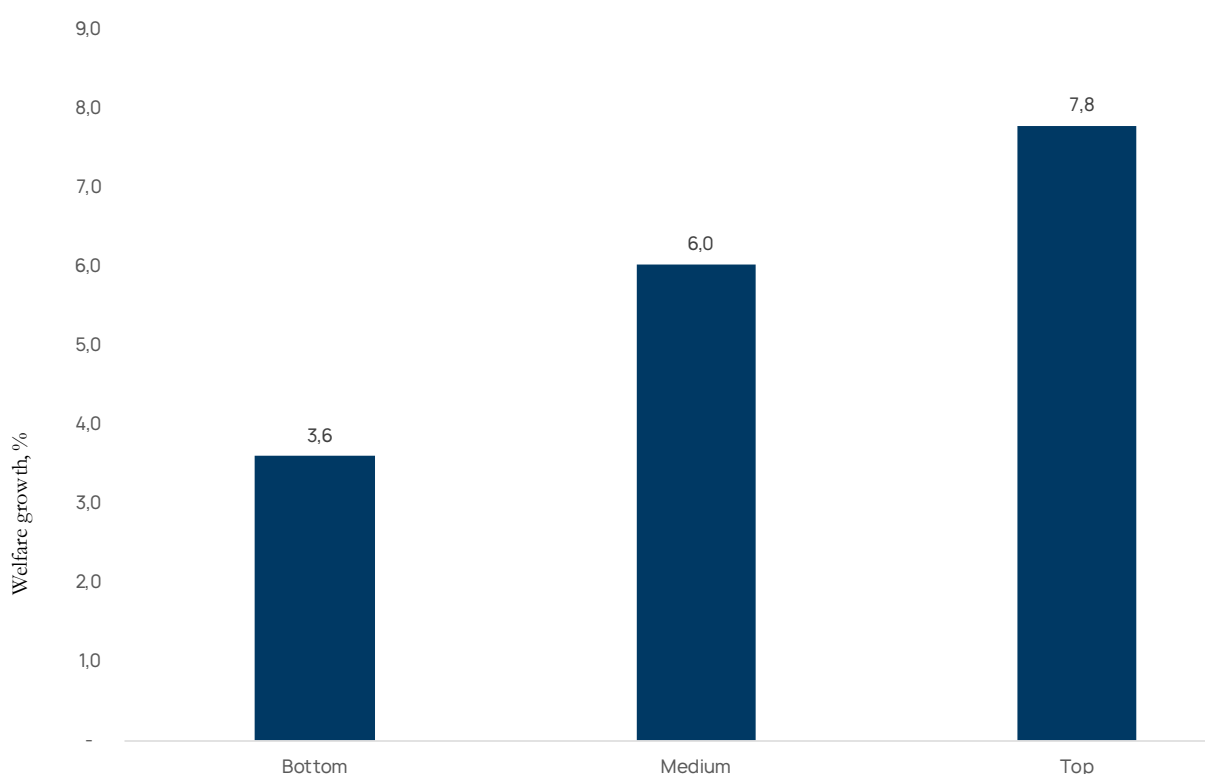
According to our calculations, Ukraine will benefit from reduced trade costs in bilateral trade with the EU due to the reduction of digital regulatory barriers (Figure 10). If regulatory heterogeneity between Ukraine and the EU

decreases from the current level (0.245) to the lower level of EU countries (0.142) and the digitalization of the economy increases (0.564 to 0.596), this will increase welfare (which can be viewed as GDP growth per capita) by 3.6%.

Therefore, under the scenario that implies achieving medium and top levels of regulatory approximation with the EU (0.092 and 0.064, respectively) and increasing the digitalization of the economy (to 0.663 and 0.719, respectively), the public welfare of Ukraine is expected to increase by 6% and 7.8%.

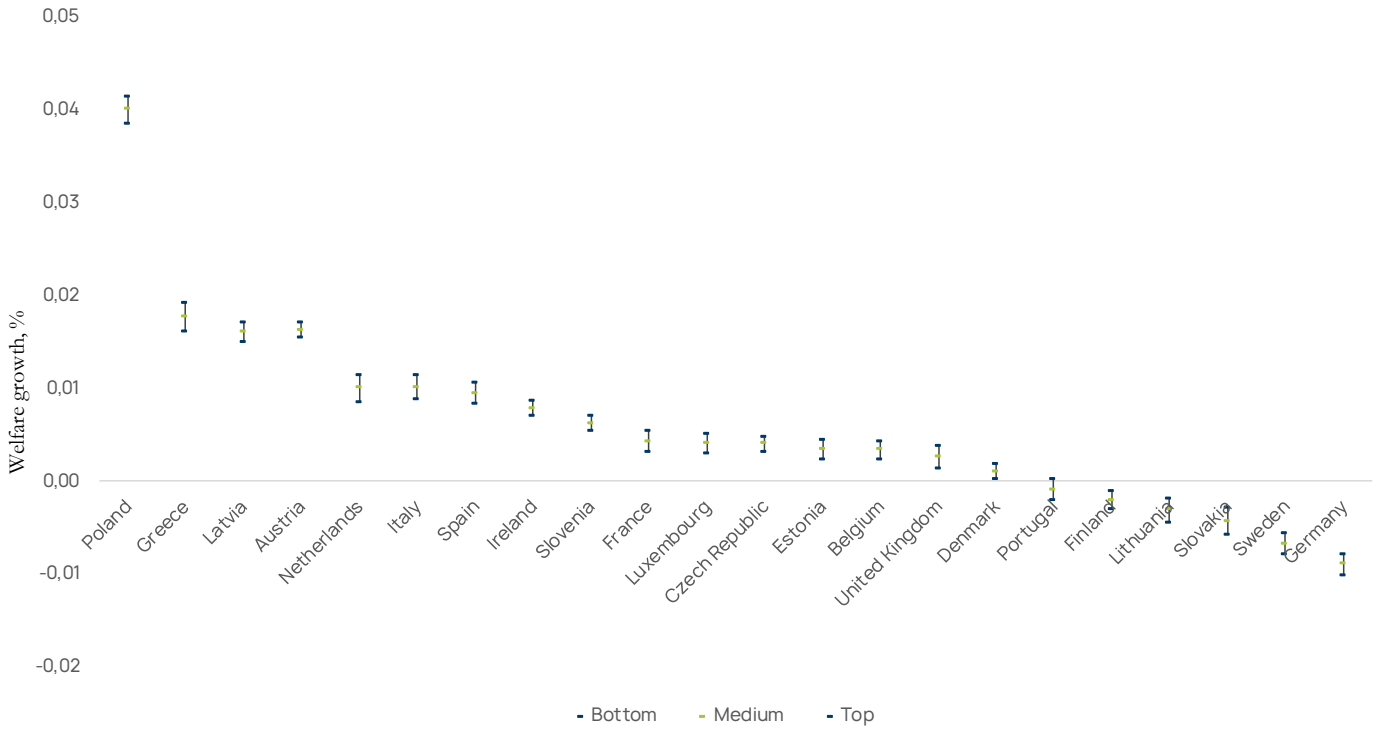
Welfare effects for the EU countries will be considerably lower than for Ukraine but mostly positive (Figure 11). The largest positive effect is expected for Poland (0.038-0.042%), Greece (0.016-0.019%), and Latvia (0.015-0.017%). On the other hand, for 6 countries the effect will potentially be negative and close to zero. These are Portugal, Finland, Lithuania, Slovakia, Sweden, and Germany.

Figure 10. Welfare effects of Ukraine's integration into the EU's DSM for Ukraine: three integration scenarios



Source: own calculations.

Figure 11. Welfare effects of Ukraine's integration into the EU's DSM for the EU countries: three integration scenarios



Source: own calculations.

Part 4. Conclusions

The results of the study show that the current level of digital development in Ukraine lags far behind the average level in the EU. Ukraine is also outpaced by the new EU member states, which have a lower level of economic and digital development among the EU countries. Ukraine's weakest indicators, as manifested by international indices and surveys, stem from the unfavourable regulatory framework for digital innovation, the gap in the development of telecommunications infrastructure, and introduction of digital technologies by the government. Therefore, these areas need to be addressed in order to improve Ukraine's position in the region and the world.

In addition, according to our estimates, Ukraine's regulatory framework is quite restrictive regarding digital trade. For Ukraine, most barriers are related to cross-border electronic payments and settlements, protection of intellectual property rights on the Internet, cross-border electronic transactions (in particular, the lack of mechanisms for the use of electronic digital signatures in foreign trade contracts, lack of mutual recognition of electronic identification and electronic trust services between Ukraine and its major trading partners etc.), other barriers (technical requirements for the use of local software and cryptography, etc.). These regulatory restrictions significantly hinder the development of cross-border cooperation and Ukraine's integration into the European and global digital space.

Ukraine's integration into the EU's DSM is a tool to facilitate Ukraine's digitalization in line with European and international standards, as well as to intensify trade between Ukraine and the EU and deepen economic integration into the EU internal market. Approximation of Ukrainian legislation and standards to EU legislation and standards will reduce regulatory differences between Ukraine and the EU in the digital sphere and accelerate Ukraine's digital development.

According to our estimations, improved digitalization and reduction of regulatory barriers between Ukraine and the EU in the digital sphere will have a positive effect for both Ukraine and the EU:

- Accelerated digitalization of the Ukrainian

economy will have a positive effect on its productivity and economic growth. According to our estimates, a 1%-increase in the digitalization of the Ukrainian economy and society may lead to an increase in Ukraine's GDP by 0.42%. Therefore, depending on the level of digitalization gradually approached by Ukraine, the cumulative positive impact on Ukraine's GDP may range from 2.4 to 12.1% of additional growth throughout the approximation period. That is, there is a significant potential for economic growth in Ukraine to be attained by increasing digitalization and productivity of various spheres of Ukrainian economy and society – including development of digital infrastructure and improving access to it, introduction of digital technologies in all areas of business, development of digital skills and competencies of citizens, and e-government.

- Approximation of Ukraine's regulatory framework and digital development to the EU level due to Ukraine's integration into the EU's DSM can increase exports of services from Ukraine to EU countries by 7.6-12.2%, and exports of goods by 11.8-17%. At the same time, exports of services from the EU to Ukraine may increase by 5.7-9.1%, and exports of goods from the EU to Ukraine by 17.7-21.7%. This is the potential for a cumulative increase in bilateral trade between Ukraine and the EU throughout the period of implementation of reforms aimed at Ukraine's regulatory and digital approximation to the EU. It includes the effect of reducing the overall level of non-tariff barriers to trade between Ukraine and the EU as a result of the digitalization of trade transactions and regulatory harmonisation with the EU in the digital sphere
- Ukraine will benefit from reduced trade costs in bilateral trade with the EU due to the reduction of digital regulatory barriers – Ukraine's welfare may improve by 3.6-7.8%. Welfare effects for the EU countries are much smaller than that for Ukraine but, for the most part, positive.

According to our estimations, the positive effect of reducing regulatory digital barriers may be more pronounced for trade in goods between Ukraine and the EU, which might be due to

the fact that digital barriers to trade in goods are more restrictive than to trade in services. It is expected that the reduction of barriers to digital trade between Ukraine and the EU as a result of integration into the EU's DSM will help reduce the overall level of non-tariff barriers and trade costs in the bilateral trade in goods and services between Ukraine and the EU (through digitalization of trade transactions and public services, etc.).

As the role of digital technologies in international trade and economy is getting increasingly more significant, Ukraine is interested in integrating into the European digital space, because the development of Ukrainian trade and economy as a whole depends on it in all areas of economic activity. According to the results of the study, there is a significant potential for trade intensification and growth of Ukraine's economy as a result of Ukraine's integration into the EU's DSM.

Annexes

Annex A. Results of the assessment of the Digitalization Index for the countries included in the model

Table A1. Digitalization Index: structure, indicators, and data

Factor	Data source	Indicator Description	Data availability, processing, normalization
1. Connectivity			
1.1 Fixed broadband subscriptions ightper 100 people	World Bank Data - International Telecommunication Union (ITU) World Telecommunication / ICT Indicators Database ¹	Fixed broadband subscriptions refers to fixed subscriptions to high-speed access to the public internet (a TCP/IP connection), at downstream speeds equal to, or greater than, 256 kbit/s.	Data are available for 2016, 2017, 2018. Data are normalized from 0 to 1.
1.2 Telecommunication Infrastructure Index	UN, E-Government Development Index ²	The Telecommunication Infrastructure Index is part of the UN e-Government Development Index and includes 4 components: the number of internet users per 100 people, the number of mobile cellular telephone subscribers per 100 inhabitants, the number of active mobile broadband subscribers per 100 inhabitants, and the number fixed broadband subscribers per 100 inhabitants.	UN index data are available for 2016 and 2018. The value for 2017 is obtained by linear interpolation. The index has a value from 0 to 1.
1.3 International Internet bandwidth per internet user (bit/s)	Network Readiness Index 2019 ³ , 2016	The indicator refers to the usage of all international links including fiber-optic cables, radio links and traffic processed by satellite ground stations and teleports to orbital satellites.	Data are available for 2019 and 2016. The values for 2017 and 2018 are determined by linear interpolation. Data are normalized from 0 to 1 (maximum value).
1.4 Fixed broadband internet tariffs, PPP USD/month	Network Readiness Index 2016 ⁴	Monthly fee for fixed broadband internet, weighted by purchasing power parity.	Data are available for 2016. The value of 2016 is duplicated for 2017 and 2018. Data are normalized from 0 to 1 (lowest rate).

1) <https://data.worldbank.org/indicator/IT.NET.BBND.P2>

2) <https://publicadministration.un.org/egovkb/en-us/Data-Center>

3) <https://networkreadinessindex.org/wp-content/uploads/2020/03/The-Network-Readiness-Index-2019-New-version-March-2020-2.pdf>

4) <https://reports.weforum.org/global-information-technology-report-2016/networked-readiness-index/>

1.5 Households with Internet access (%)	Network Readiness Index 2019 ⁵ , 2016	Share of households that have access to the Internet at home through a fixed or mobile network. The Internet is available for use by all members of the household at any time.	Data are available for 2019 and 2016. Values for 2017 and 2018 were determined by linear interpolation. Data are normalized from 0 to 1.
2. Human Capital: Digital Skills			
2.1 Level of digital skills among population	World Bank, data – World Economic Forum Global Competitiveness Index ⁶	The indicator has a value from 1 to 7. Expert answers to the question “In your country, to what extent does the active population possess sufficient digital skills (e.g., computer skills, basic coding, digital reading)?” [1 = not all; 7 = to a great extent]	Data are available for 2017 and 2018. For 2016, the values of 2017 were used. Data are normalized from 0 to 1 (highest level).
3. Use of Internet services by citizens			
3.1 Individuals using the internet - share of people who use the internet at least once in 3 months (% of population)	World Bank, ITU World Telecommunication/ ICT Indicators Database ⁷	Internet users are individuals who have used the internet (from any location) in the last 3 months.	Data are available for 2016, 2017, 2018. Data are normalized from 0 to 1.
3.2 Made digital payments in the past year, (% age 15+) - percentage of people aged 15+ who have made a digital payment in the past year (%)	World Bank, Global Findex database ⁸	The percentage of respondents who report using mobile money, a debit or credit card, or a mobile phone to make a payment from an account, or report using the internet to pay bills or to buy something online, in the past 12 months. It also includes respondents who report paying bills or sending remittances directly from a financial institution account or through a mobile money account in the past 12 months	Data are available for 2017 and 2014. For 2018, the values of 2017 were used. The values for 2016 were obtained by linear interpolation of the values of 2014 and 2017. Data are normalized from 0 to 1
4. Integration of digital technology by businesses			
4.1 ICT use of for business-to-business transactions	World Bank, data of the World Economic Forum, Executive Opinion Survey ⁹	The indicator has a value from 1 to 7. Expert answers to: “In your country, to what extent do businesses use ICTs for transactions with other businesses? [1 = not at all; 7 = to a great extent].	Data are available only for 2013-2016. The values of 2016 were duplicated for 2017 and 2018. Data are normalized from 0 to 1.

5) <https://networkreadinessindex.org/wp-content/uploads/2020/03/The-Network-Readiness-Index-2019-New-version-March-2020-2.pdf>

6) https://tcdata360.worldbank.org/indicators/h945a9708?country=BRA&indicator=41400&viz=line_chart&years=2017,2019

7) <https://data.worldbank.org/indicator/IT.NET.USER.ZS>

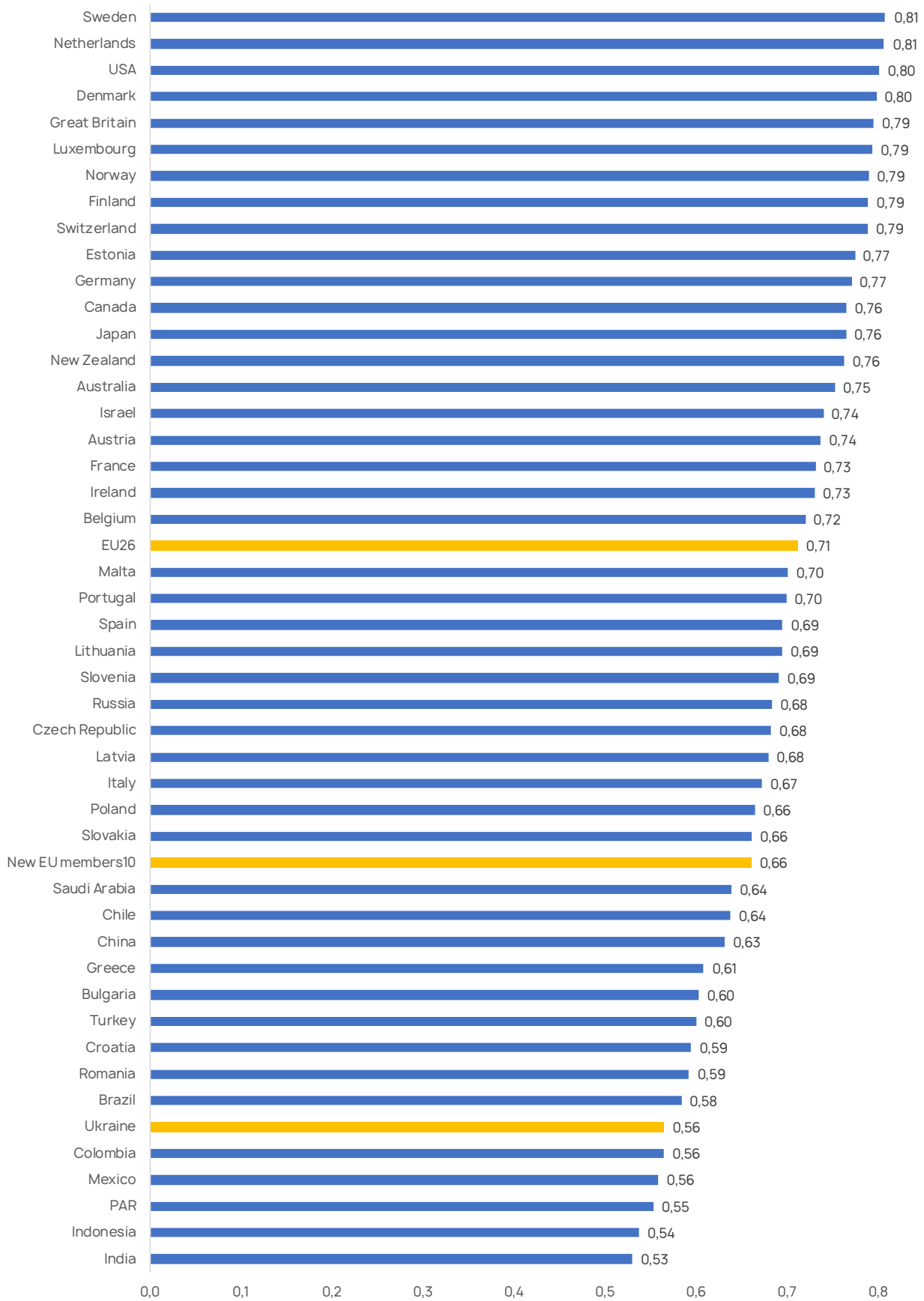
8) <https://databank.worldbank.org/reports.aspx?source=1228>

9) https://tcdata360.worldbank.org/indicators/hf0d27aa9?country=UKR&indicator=3443&countries=BRA&viz=line_chart&years=2013,2016

4.2 Business-to-consumer internet use	World Bank, data of World Economic Forum, Executive Opinion Survey	The indicator has a value from 1 to 7. Expert answers to: "In your country, to what extent do businesses use the Internet for selling their goods and services to consumers?" [1 = not at all; 7 = to a great extent]	Data are available only for 2013-2016. The values of 2016 were duplicated for 2017 and 2018. Data are normalized from 0 to 1.
5. Digital public services			
5.1 Index of digital public services (UN Online Service Index)	UN, E-Government Development Index ¹⁰	The Online Service Index (OSI) is part of the UN e-Government Development Index and is based on an expert survey that evaluates national approaches to online services, open government data, e-participation, multichannel service delivery, mobile services, innovative partnerships through the use of ICT, etc.	UN index data are available for 2016 and 2018. The value for 2017 is obtained by linear interpolation. The OSI index has a value from 0 to 1.

¹⁰) <https://publicadministration.un.org/egovkb/en-us/Data-Center>

Figure A1. Digitalization Index estimates, 2018



Source: own calculations based on international data of the UN, World Bank, ITU, WEF.

Table A2. Estimates of the Digitalization Index and its components for Ukraine and EU Member States, 2018

Components and indicators of the Digitalization Index		Ukraine	EU26*	New EU Member States (10 CEE) **
Overall Digitalization Index		0.56	0.71	0.66
Connectivity	1.1 Fixed broadband subscriptions	0.13	0.33	0.27
	1.2 Technology infrastructure index	0.44	0.69	0.61
	1.3. International Internet bandwidth	0.01	0.03	0.01
	1.4 Fixed broadband internet tariffs	0.93	0.81	0.83
	1.5 Households with Internet access	0.53	0.82	0.78
	Overall connectivity index	0.41	0.53	0.49
Human capital	2.1 Level of digital skills among population	0.63	0.69	0.66
	Overall index of human capital	0.63	0.69	0.66
Use of Internet services by citizens	3.1 Percentage of people who use the internet at least once in 3 months	0.63	0.83	0.78
	3.2 Percentage of people aged 15+ who made a digital payment in the past year (% age 15+)	0.47	0.83	0.71
	Overall index of use of Internet services by citizens	0.55	0.83	0.75
Integration of Digital Technology by businesses	4.1 ICT use for business-to-business transactions	0.63	0.77	0.74
	4.2 Business-to-consumer Internet use	0.73	0.76	0.75
	Overall index of integration of digital technology by businesses	0.68	0.76	0.75
Digital public services	5.1 Index of digital public services	0.57	0.85	0.76
	Overall index of digital public services	0.57	0.85	0.76

Note: *Average value for 26 EU Member States for which data were available.

**Average value for 10 EU member states, including Estonia, Lithuania, Latvia, Slovenia, Poland, Slovakia, the Czech Republic, Croatia, Bulgaria, and Romania.

Annex B. Results of the Digital STRI for Ukraine

The OECD questionnaire contains questions to be answered “yes” or “no”.¹ The answer is then assigned a value of 0 in the absence of trade restrictions and a value of 1 when regulations restrict digital trade.

The assessment also takes into account the regulatory and market characteristics of the information and communications technology (ICT) market. In particular, for the Infrastructure and Connectivity component, assessment of regulatory measures depends on whether there are suppliers in the market with a significant market advantage. If there is at least one such company, then regulation (in particular, concerning prices and conditions of interconnection) is considered necessary (respectively it is assigned a value of 0).

According to the OECD methodology, measures related to infrastructure and connectivity are assigned more weight than all other components (infrastructure and connectivity make up 55% of the index, all the other measures together account for 45%). This ratio reflects the fundamental role of high-quality infrastructure and seamless connectivity for digital transactions.²

Table B1. Results of expert survey and analysis of the regulatory framework for calculating the Digital STRI for Ukraine, 2016-2018

	Factor	Answer “yes” or “no”			1 – barrier, 0 - no barrier			Weights	Scores for the index		
		2016	2017	2018	2016	2017	2018		2016	2017	2018
Infrastructure and connectivity	Interconnection is mandated (fixed)	Yes	Yes	Yes	0	0	0	0.040	0	0	0
	Interconnection is mandated (mobile)	Yes	Yes	Yes	0	0	0	0.040	0	0	0
	Interconnection prices and conditions are regulated (fixed)	Yes	Yes	Yes	0	0	0	0.040	0	0	0
	Interconnection prices and conditions are regulated (mobile)	Yes	Yes	Yes	0	0	0	0.040	0	0	0
	Interconnection reference offers are made public (fixed)	Yes	Yes	Yes	0	0	0	0.040	0	0	0
	Interconnection reference offers are made public (mobile)	Yes	Yes	Yes	0	0	0	0.040	0	0	0
	Vertical separation is required (fixed)	No	No	No	0	0	0	0.040	0	0	0
	Vertical separation is required (mobile)	No	No	No	0	0	0	0.040	0	0	0
	Memo: Non-discriminatory Internet traffic management is mandated*	Yes	Yes	Yes							

1) <https://www.oecd-ilibrary.org/docserver/16ed2d78-en.pdf?expires=1596709812&id=id&accname=guest&checksum=9EB9F2E09E70B97FE-BCFFF77F34DAB7D>

2) https://www.oecd-ilibrary.org/trade/the-oecd-digital-services-trade-restrictiveness-index_16ed2d78-en;jsessionid=bSF6bAbXatG2RuF-doB-fGs4f.ip-10-240-5-58

Infrastructure and connectivity	Memo: There is at least one dominant firm in the market segment considered** (fixed)	Yes	Yes	Yes							
	Memo: There is at least one dominant firm in the market segment considered**, traffic termination (mobile)	Yes	Yes	Yes							
	Memo: There is at least one dominant firm in the market segment considered**, traffic origination (mobile)	n/a	n/a	n/a							
	Restrictions on the use of communication services (including through virtual private networks or leased lines)	No	No	No	0	0	0	0.040	0	0	0
	Memo: Free cross-border transfer of personal data or application of the accountability principle*	No	No	No							
	Cross-border transfer of personal data is possible when certain private sector safeguards are in place	Yes	Yes	Yes	0	0	0	0.040	0	0	0
	Cross-border data flows: cross-border transfer of personal data is possible to countries with substantially similar privacy protection laws	Yes	Yes	Yes	1	1	1	0.040	0.040	0.040	0.040
	Cross-border data flows: cross-border transfer is subject to approval on a case-by-case basis	No	No	No	0	0	0	0.040	0	0	0
	Cross-border data flows: Certain data must be stored locally	Yes	Yes	Yes	1	1	1	0.040	0.040	0.040	0.040
	Cross-border data flows: transfer of data is prohibited	No	No	No	0	0	0	0.040	0	0	0
Overall Infrastructure and connectivity index								0.08	0.08	0.08	
Electronic transactions	Discriminatory conditions for licenses to engage in e-commerce	No	No	No	0	0	0	0.021	0	0	0
	Memo: License or authorisation is required to engage in e-commerce**	No	No	No							
	Online tax registration and declaration is available to non-resident foreign providers	No	No	No	1	1	1	0.021	0.021	0.021	0.021

	National contract rules for cross-border transaction deviate from internationally standardised rules	Yes	Yes	Yes	1	1	1	0.021	0.021	0.021	0.021
	Laws or regulations explicitly protect confidential information	Yes	Yes	Yes	0	0	0	0.021	0	0	0
	Laws or regulations provide electronic signature with the equivalent legal validity with hand-written signature	No	Yes	Yes	1	0	0	0.021	0.021	0	0
	Dispute settlement mechanism exists to resolve disputes arising from cross-border digital trade	Yes	Yes	Yes	0	0	0	0.021	0	0	0
Overall Electronic Transactions Index									0.06	0.04	0.04
Payment systems and electronic payments	Discriminatory access to payment methods	Yes	Yes	Yes	1	1	1	0.018	0.018	0.018	0.018
	National payment security standards deviate from international standards	Yes	Yes	Yes	1	1	1	0.018	0.018	0.018	0.018
	Restrictions on internet banking or insurance	Yes	Yes	Yes	1	1	1	0.018	0.018	0.018	0.018
Overall Payment Systems Index									0.06	0.06	0.06
Intellectual property rights	Foreign firms are discriminated against on trademark protection	Yes	Yes	Yes	1	1	1	0.022	0.022	0.022	0.022
	Discriminatory treatment of foreigners for the protection of copyrights and related rights	Yes	Yes	Yes	1	1	1	0.022	0.022	0.022	0.022
	Memo: Exceptions to copyright protection are limited in accord with international rules*	Yes	Yes	Yes							
	Enforcement of intellectual property rights: judicial or administrative measures and remedies are available	Yes	Yes	Yes	0	0	0	0.022	0	0	0
	Enforcement of intellectual property rights: provisional measures are available	No	Yes	Yes	1	0	0	0.022	0.022	0	0
	Enforcement of intellectual property rights: criminal proceedings and penalties are available	Yes	Yes	Yes	0	0	0	0.022	0	0	0
Overall Intellectual Property Rights index									0.06	0.04	0.04
Other barriers affecting trade in digitally enabled services	Performance requirements affecting cross-border digital trade (e. g. mandatory use of local software and encryption or mandatory technology transfer)	Yes	Yes	Yes	1	1	1	0.022	0.022	0.022	0.022

Other barriers affecting trade in digitally enabled services	Limitations on downloading and streaming affecting cross-border digital trade	No	No	No	0	0	0	0.022	0	0	0
	Restrictions on online advertising	No	No	No	0	0	0	0.022	0	0	0
	Commercial presence is required in order to provide cross-border services	No	No	No	0	0	0	0.022	0	0	0
	Local presence is required in order to provide cross-border services	No	No	No	0	0	0	0.022	0	0	0
	Firms have redress when business practices restrict competition in a given market	Yes	Yes	Yes	0	0	0	0.022	0	0	0
	Other restrictions on digitally enabled services	Yes	Yes	Yes	1	1	1	0.022	0.022	0.022	0.022
Overall index of Other Barriers Affecting Trade in Digitally Enabled Services									0.04	0.04	0.04
Overall Digital STRI									0.31	0.26	0.26

Note* For these measures, data is collected only for information purposes.

** These memos are not scored but affect the scoring of other measures.

Weights are assigned in line with the OECD methodology.

Annex C. Gravity Model Methodology

Theory

The gravity model formula is as follows:

$$X_{ij} = \frac{Y_i E_j}{Y} \times \left(\frac{\tau_{ij}}{P_j \Omega_i} \right)^{1-\sigma} \quad (1)$$

where

X_{ij} – volume of exports in USD from country i (exporter) to country j (importer)

Y_i – production capacity of the exporting country (GDP)

E_j – the size of the consumer market of the importing country (costs in monetary terms)

Y – world GDP

σ – elasticity of substitution between different goods, in particular between domestic and imported goods. It measures how much (in percentage) the demand for imported goods will decrease if the price increases by 1%. In empirical models, its value is usually about 4-5.

τ_{ij} – trade costs between the exporter and the importer, which include transport costs, border crossing costs, payment of duties, satisfaction of non-tariff requirements in importing countries, and payment for insurance services.

$P_j \tau \Omega_i$ – “price indices” that cover all relevant information about the state of all countries of the world economy, their geographical position relative to each other, all trade costs between all countries, production and costs in all countries. These two figures are significant because they bring together all relevant information on the global trade balance in two numbers. These two figures are referred to as multilateral import and export resistance.

Empirical implementation

We estimate the gravity model by applying the pseudo maximum likelihood estimation¹ (PPML, see Silva and Tenreyro, 2006) based on the following equation:

$$X_{ijt} = \exp \left(\gamma_{\text{ВіДСТ}} \ln(\text{ВіДСТ}_{ij}) + \gamma_{\text{FTA}} \text{FTA}_{ijt} + Z_{ijt} \gamma_Z + \alpha_{\text{Hetero}} \text{Hererogeneity}_{ijt} + \chi_i + \xi_j \right) \times v_{ij}$$

FTA – an indicator of the existence of a free trade agreement

Z_{ijt} – records all variables that explain trading costs

$\text{Hererogeneity}_{ijt}$ – iiindex of regulatory framework heterogeneity in the digital sphere between country i and country j

Fixed χ_i and ξ_j effects are added to take into account the multilateral importer and exporter resistance. Estimated trade flows are determined using the following equation:

$$\hat{X}_{ij} = \exp \left(\hat{\gamma}_{\text{ВіДСТ}} \ln(\text{ВіДСТ}_{ij}) + \hat{\gamma}_{\text{FTA}} \text{FTA}_{ij} + \hat{\alpha}_{\text{Hetero}} \text{Hererogeneity}_{ij} + Z_{ij} \hat{\gamma}_Z + \hat{\chi}_i + \hat{\xi}_j \right)$$

$$\hat{X}_{ij}^{\text{digital}} = \beta_{\text{digital}} * \text{Digitalization} * \hat{X}_{ij}$$

β_{digital} – an estimate of the impact of changes in the level of digitalization on the economy of Ukraine
Digitalization – stands for the potential level of digitalization of Ukraine's economy in accordance with the selected scenarios.

And the index of under- or overtrading is as follows:

$$TP_{ij} = \hat{X}_{ij}^{\text{digital}} - X_{ij}$$

A negative value of the index indicates the potential for export growth, and a positive value indicates an expected decline in exports in the long run.

1) Poisson Pseudo Maximum Likelihood estimator (PPML)

Annex D. Methodology for Estimating the Welfare Effect

Model

Suppose that the economy includes N countries indexed as $i = 1 \dots N$. Every country has Q_i units of differentiated good.² In the country j there is a representative consumer with a utility function that has a constant elasticity of substitution (CES). Trade is costly – it requires $\tau_{ij} \geq 1$ units of good i to deliver one unit of this product from country i to j ; $\tau_{ij} = 1$ only when $i = j$. Then

$$X_{ij} = \frac{Y_i E_j}{Y_w} \left(\frac{\tau_{ij}}{\Omega_i P_j} \right)^{1-\sigma} \quad (1)$$

Where X_{ij} represents exports from country i to country j , $Y_i = \sum_j X_{ij}$ total income of country i , and $E_j = \sum_i X_{ij}$ stands for total costs of country j . Next, we assume that current trade imbalances persist over the long term, so

$$E_i = \mu_i Y_i, \forall i \in 1, 2, \dots, N.$$

Global ties are aggregated in two indicators: multilateral export resistance

$$\Omega_i^{1-\sigma} = \sum_j \frac{E_j}{Y_w} \left(\frac{\tau_{ij}}{P_j} \right)^{1-\sigma} \quad (2)$$

and multilateral import resistance

$$P_j^{1-\sigma} = \sum_i \frac{Y_i}{Y_w} \left(\frac{\tau_{ij}}{\Omega_i} \right)^{1-\sigma}. \quad (3)$$

Finally, the ex-factory price in country i at equilibrium is characterized as follows

$$p_i = \left(\frac{Y_i}{Y_w} \right)^{1/(1-\sigma)} \frac{1}{\Omega_i} \quad (4)$$

Following Anderson, Larch, and Yotov (2018), we estimate the multilateral resistance to import and export in the baseline and hypothetical scenarios using the pseudo-maximum likelihood estimator³ (PPML, see Silva and Tenreyro, 2006). The assessed model is as follows:

$$X_{ijt} = \exp(\gamma_{\text{вiдст}} \ln(\text{вiдст}_{ij}) + \gamma_{\text{FTA}} \text{FTA}_{ijt} + Z_{ijt} \gamma_Z + \alpha_{\text{Hetero}} \text{Heterogeneity}_{ijt} + \chi_i + \xi_j) \times v_{ij} + u_{ij} \quad (5)$$

We limit the coefficients of the variables to the values estimated at the previous stage.

$$\hat{X}_{ijt} = \exp(\hat{\gamma}_{\text{вiдст}} \ln(\text{вiдст}_{ij}) + \hat{\gamma}_{\text{FTA}} \text{FTA}_{ijt} + \hat{\alpha}_{\text{Hetero}} \text{Heterogeneity}_{ijt} + Z_{ijt} \hat{\gamma}_Z + \hat{\chi}_i + \hat{\xi}_j) + u'_{ij} \quad (6)$$

Next, we change $\text{Heterogeneity}_{ijt}$ to reflect changes in hypothetical scenarios and re-estimate the model.

2) The model can accommodate a more detailed structure of production, but our focus in this paper is on welfare changes due to changes in trade costs, while capital flows, demographics and migration, and technology are fixed.

3) Poisson Pseudo Maximum Likelihood estimator (PPML)

Using the results of Fally (2015), we calculate the multilateral resistance to import and export based on the following formulae:

$$\widehat{P}_j^{1-\sigma} = E_j \exp \exp (-\widehat{\xi}_j) / E_0 \quad (7)$$

$$\widehat{P}_j^{1-\sigma} = E_j \exp \exp (-\widehat{\xi}'_j) / E_0 \quad (8)$$

$$\widehat{\Omega}_i^{1-\sigma} = E_0 Y_i \exp (-\widehat{\chi}_i) \quad (9)$$

$$\widehat{\Omega}_i^{1-\sigma} = E_0 Y_i \exp (-\widehat{\chi}'_i) \quad (10)$$

Where E_0 represents the level of costs of the country for which the multilateral resistance to import is normalized to $P_0 = 1$.⁴

Finally, we adjust prices and aggregates that appear in the new equilibrium according to the algorithm proposed by Anderson et al. (2018). This algorithm takes into account the adjustment of export prices due to changes in trade costs, which further leads to changes in income, costs and trade. In particular, performing calculations of the conditional equilibrium model, we modify the ex-factory prices according to the following formula:

$$\frac{p'_i}{p_i} = \frac{\widehat{\Omega}_i}{\overline{\Omega}_i} = \left\{ \frac{\exp \exp (-\widehat{\chi}_i)}{\exp \exp (-\overline{\chi}_i)} \right\}^{1/(1-\sigma)} \quad (11)$$

Next, we estimate the new level of income and expenses, as well as bilateral trade flows as follows:

$$Y'_i = \frac{p'_i}{p_i} Y_i \quad (12)$$

$$E'_j = \frac{p'_j}{p_j} E_j \quad (13)$$

and

$$X'_{ij} = \frac{\tau^{1-\sigma} Y'_i E'_j \widehat{\Omega}_i^{1-\sigma} \overline{P}_j^{1-\sigma}}{\tau^{1-\sigma} Y_i E_j \overline{\Omega}_i^{1-\sigma} \overline{P}_j^{1-\sigma}} X_{ij} \quad (14)$$

Finally, we calculate the model for the new equilibrium, following the same procedure as for the conditional equilibrium. This iterative process continues until the ex-factory price coincides with the values of total general equilibrium. Changes in welfare at full general equilibrium are calculated as follows:

$$\widehat{W} = 100\% \times \left(\frac{\frac{Y'_i}{\overline{P}_i}}{\frac{Y_i}{\overline{P}_i}} - 1 \right) \quad (15)$$

4) We use New Zealand as the baseline country.

Annex E. General results of the assessment of the relationship between the digitalization of economy and productivity and economic growth

For the “log of output” variable, we used Penn World Tables 9.1 (PWT) data, namely “output-side real GDP at chained PPPs” (Ingdp0). We also used “expenditure-side real GDP” to test the reliability of the model. Data for capital, labour and human capital are obtained from PWT9.1. The Digitalization Index in 2016-2018 was calculated on the basis of a number of digital indicators, combined into five components that characterize different areas of the digital economy and society. Table D1 presents generalized statistics on these variables.

Table E1. Generalized statistics on model variables

Variable	Source	Description	Mean	Stand. Deviation	Min.	Max.
Ingdp0	PWT	Output-side real GDP at chained PPPs (in mil. 2011US\$)	13.44	1.54	10.38	16.73
Ingdp1	PWT	Expenditure-side real GDP at chained PPPs (in mil. 2011US\$)	13.51	1.49	10.55	16.73
dgt	UN, WB	Composite Digitalization index	0.68	0.09	0.47	0.81
hc	PWT	Human capital* It is based on Barro and Lee (2013) log of years of schooling	3.22	0.44	2.10	3.81
InK	PWT	Capital stock at current PPPs (in mil. 2011US\$)	15.08	1.49	12.08	18.48
InL	PWT	Number of persons engaged (in millions)	2.39	1.71	-0.89	6.68

The results are presented in Table E2.

Table E2. Evaluation of the production function. Model with fixed effects

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Ln GDP	Ln GDP	Ln GDP	TFP	Ln GDP	TFP	Ln GDP	Ln GDP
Digitalization	0.790*	0.561+		0.415+		0.295	0.738*	-0.420
	(0.323)	(0.302)		(0.236)		(0.218)	(0.342)	(1.165)
Ln Capital	0.422**	0.470**	0.546**		0.558**		0.406**	0.395**
	(0.129)	(0.120)	(0.125)		(0.114)		(0.134)	(0.134)
Ln Labor	0.647*	0.771**	0.879**		0.937**		0.586+	0.587+
	(0.269)	(0.252)	(0.267)		(0.243)		(0.297)	(0.297)
Human capital							0.124	-0.165
							(0.244)	(0.369)
Digitalization× Human capital								0.415
								(0.399)
Observations	84	84	84	84	84	84	84	84
R2	0.715	0.750	0.672	0.070	0.728	0.043	0.717	0.725

In regression models (1), (3), (7), (8) the dependent variable is the natural logarithm of the production-side real GDP, $\ln gdp_0$. In regressions (2), (5) the dependent variable is the natural logarithm of the expenditure-side real GDP, $\ln gdp_1$. Models (1), (2), (7) and (8) were evaluated in one step. We also estimate equations (1) and (2) in two steps in (3)-(6). In model (4), we regress the residuals obtained in specification (3) to the Digitalization Index. In model (6) we regress residuals from model (5) to the Digitalization Index. This two-step procedure reflects the idea that the variables L and K actually include a choice for companies that hire workers and invest in capital, while the level of technology and digitalization is a given value. In (7) and (8) we add the "human capital" variable to the model. The results show that digitalization increases productivity only when there are skilled workers in the country.

For our assessment, we used model (7), which includes human capital and digitalization. According to the results of this model, the transition from the minimum to the maximum level of digitalization of these countries (according to 2018 data, see Figure A1) leads to GDP growth:

$$GDP\ growth = 100 * (\exp\{0,738 \times (0.81 - 0.53)\} - 1) = 22,9\%$$

Accordingly, a 1% increase of digitalization in Ukraine (from the current level of 0.564 to 0.57) will create conditions for the following growth of Ukraine's GDP:

$$GDP\ growth^{Ukraine} = 100 * (\exp\{0,738 \times (0,57 - 0,564)\} - 1) = 0,42\%$$

Annex F. The gravity model estimates

Table F1 illustrates the estimated coefficients for gravity models of trade in goods and services. The digital STRI heterogeneity between countries in terms of trade in digital services is negative and is statistically significant for both goods and services. Accordingly, its value can be interpreted as follows: as regulatory barriers between the two countries increase/decrease, the volume of trade in goods and services between them decreases / increases.

Using these estimates, the potential changes in trade volumes were assessed under three scenarios. Tables F2 and F3 present the evaluation results for individual countries.

Table F1. Generalized statistics for model variables.

	Goods	Services
Free Trade Agreement	0.51**	0.42
Border	0.89***	0.69**
Colony	-0.09	-0.26
Religion	0.16	0.62***
Language	0.28***	0.52***
Distance	-0.22	-0.39
Import duties	-6.32	
Digital STRI Heterogeneity Index	-2.68***	-3.07***
Fixed effects of countries		
Observations	1715	1716

Table F2. Estimated effects of Ukraine's integration into the EU's DSM on the exports of services from Ukraine to the EU and other countries*

	Current exports, \$ million**	Potential exports, \$ million			Potential change in exports, %		
		Bottom	Medium	Top	Bottom	Medium	Top
European Union, 28 countries	4,000	4,303	4,394	4,485	7.6%	9.9%	12.1%
European Union, 22 countries*	3,154	3,395	3,467	3,540	7.6%	9.9%	12.2%
Austria	197	265	276	286	34.7%	40.3%	45.7%
Belgium	92	92	93	95	0.2%	1.6%	3.0%
Czech Republic	83	87	89	91	5.5%	7.5%	9.6%
Germany	582	506	504	504	-13.2%	-13.4%	-13.4%
Denmark	153	145	147	148	-4.8%	-4.0%	-3.1%
Spain	96	106	108	111	10.3%	12.9%	15.6%
Estonia	168	169	171	173	0.2%	1.6%	3.0%
Finland	30	28	28	28	-8.8%	-8.5%	-8.0%
France	151	152	154	157	1.0%	2.5%	4.0%
UK	557	558	566	574	0.2%	1.6%	3.1%
Greece	24	27	28	29	16.4%	19.7%	23.0%
Ireland	56	65	67	69	16.3%	19.6%	22.9%
Italy	137	152	156	159	11.2%	13.9%	16.6%
Lithuania	46	44	44	44	-4.7%	-4.0%	-3.0%
Luxemburg	12	12	12	12	0.2%	1.6%	3.0%
Latvia	68	87	90	93	27.6%	32.3%	36.9%
The Netherlands	191	201	205	209	5.5%	7.5%	9.5%
Poland	343	542	571	598	58.0%	66.4%	74.4%
Portugal	5	5	5	5	-3.9%	-3.1%	-2.1%
Slovakia	43	41	42	42	-4.1%	-3.2%	-2.2%
Slovenia	20	22	23	23	10.3%	13.0%	15.6%
Sweden	101	88	88	88	-13.2%	-13.4%	-13.4%
Other countries (excluding Russia)	2,586	2,626	2,589	2,550	1.6%	0.1%	-1.4%
Other countries	5,916	5,640	5,525	5,407	-4.7%	-6.6%	-8.6%
New Zealand	1	0	0	0	-5.4%	-7.4%	-9.5%
Australia	3	3	3	3	-9.3%	-11.6%	-13.9%
Brazil	1	1	1	1	8.7%	7.8%	6.8%
Canada	86	105	105	105	21.1%	21.4%	21.2%
Switzerland	887	805	784	763	-9.3%	-11.6%	-14.0%
Chile	0	0	0	0	39.1%	40.8%	42.0%
China	105	95	92	90	-9.5%	-11.9%	-14.2%
Colombia	1	2	2	2	55.6%	58.7%	61.1%
Indonesia	1	1	1	1	36.4%	38.0%	39.0%
India	98	94	93	91	-3.4%	-5.2%	-7.2%
Israel	198	226	226	225	14.6%	14.3%	13.7%
Japan	10	8	8	8	-13.6%	-16.3%	-19.0%
Mexico	0	0	0	0	-4.6%	-6.6%	-8.6%
Norway	34	31	30	29	-9.3%	-11.7%	-14.0%
Russian Federation	3,330	3,014	2,936	2,858	-9.5%	-11.8%	-14.2%
Saudi Arabia	6	6	6	6	4.0%	2.8%	1.4%
Turkey	176	171	167	164	-3.1%	-4.9%	-6.8%
USA	975	1,069	1,062	1,053	9.7%	9.0%	8.0%
RSA	5	8	8	9	64.9%	68.8%	71.9%

Source: own calculations.

Note: *The model is based on data estimates for 42 countries (including 22 EU countries) due to limitations in available data. All the above estimates of changes in exports are calculated for 28 EU countries by extrapolating the results obtained for 22 EU countries. ** As of 2018

Table F3. Estimated effects of Ukraine's integration into the EU's DSM on the exports of goods from Ukraine to the EU and other countries*

	Current exports, \$ million**	Potential exports, \$ million			Potential change in exports, %		
		Bottom	Medium	Top	Bottom	Medium	Top
European Union, 28 countries	20,157	22,536	23,060	23,584	11.8%	14.4%	17.0%
European Union, 22 countries *	16,927	18,923	19,365	19,804	11.8%	14.4%	17.0%
Austria	553	720	747	772	30.2%	35.0%	39.6%
Belgium	604	600	606	614	-0.7%	0.5%	1.7%
Czech Republic	878	915	930	945	4.2%	5.9%	7.6%
Germany	2,208	1,921	1,914	1,911	-13.0%	-13.3%	-13.5%
Denmark	250	237	238	240	-5.2%	-4.6%	-3.9%
Spain	1,370	1,487	1,518	1,548	8.6%	10.8%	13.0%
Estonia	152	151	153	155	-0.7%	0.5%	1.7%
Finland	81	73	74	74	-9.0%	-8.8%	-8.5%
France	541	541	548	555	0.1%	1.3%	2.6%
UK	584	581	587	594	-0.7%	0.5%	1.7%
Greece	280	319	327	335	14.0%	16.9%	19.7%
Ireland	78	88	91	93	13.9%	16.8%	19.6%
Italy	2,629	2,874	2,935	2,996	9.3%	11.7%	14.0%
Lithuania	343	325	327	329	-5.2%	-4.6%	-3.9%
Luxemburg	7	7	7	7	-0.7%	0.5%	1.7%
Latvia	294	365	377	388	23.9%	28.0%	31.9%
The Netherlands	1,604	1,670	1,697	1,725	4.1%	5.8%	7.6%
Poland	3,257	4,892	5,125	5,347	50.2%	57.3%	64.1%
Portugal	247	236	238	240	-4.5%	-3.8%	-3.0%
Slovakia	864	824	830	837	-4.6%	-3.9%	-3.1%
Slovenia	33	36	37	38	8.6%	10.8%	13.0%
Sweden	70	61	61	61	-13.0%	-13.4%	-13.5%
Other countries (excluding Russia)	10,550	10,524	10,367	10,199	-0.2%	-1.7%	-3.3%
Other countries	14,202	13,824	13,583	13,330	-2.7%	-4.4%	-6.1%
New Zealand	5	5	5	5	-5.9%	-7.8%	-9.9%
Australia	30	27	27	26	-9.4%	-11.7%	-14.0%
Brazil	45	48	48	47	7.0%	6.2%	5.1%
Canada	78	92	92	92	18.2%	18.3%	18.1%
Switzerland	109	98	96	94	-9.4%	-11.7%	-14.0%
Chile	8	11	11	11	34.0%	35.5%	36.4%
China	2,200	1,987	1,936	1,886	-9.7%	-12.0%	-14.3%
Colombia	39	57	58	59	48.3%	50.9%	53.0%
Indonesia	616	812	820	825	31.8%	33.0%	33.8%
India	2,176	2,089	2,049	2,008	-4.0%	-5.8%	-7.7%
Israel	580	652	650	646	12.4%	12.0%	11.4%
Japan	232	201	194	188	-13.5%	-16.1%	-18.7%
Mexico	156	148	145	142	-5.1%	-7.0%	-9.0%
Norway	28	25	25	24	-9.5%	-11.8%	-14.0%
Russian Federation	3,652	3,300	3,216	3,132	-9.7%	-12.0%	-14.3%
Saudi Arabia	749	770	761	750	2.8%	1.6%	0.2%
Turkey	2,352	2,266	2,224	2,180	-3.7%	-5.5%	-7.3%
USA	1,113	1,202	1,193	1,182	8.0%	7.2%	6.2%
RSA	34	34	34	34	0.0%	0.0%	0.0%

Source: own calculations.

Note: * The model is based on data estimates for 42 countries (including 22 EU countries) due to limitations in available data. All the above estimates of changes in exports are calculated for 28 EU countries by extrapolating the results obtained for 22 EU countries. ** As of 2018.

