European Commission

ISSN 1725-3187 (online)
ISSN 1016-8060 (print)

EUROPEAN ECONOMY

Economic Papers 529 | September 2014

The Economic Impact of Digital Structural Reforms

Dimitri Lorenzani, Janos Varga

Economic and Financial Affairs

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Comments and enquiries should be addressed to:

European Commission
Directorate-General for Economic and Financial Affairs
Unit Communication and interinstitutional relations
B-1049 Brussels
Belgium
E-mail: ecfin-info@ec.europa.eu

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KC-AI-14-529-EN-N (online)
ISBN 978-92-79-35178-5 (online)
doi:10.2765/70944 (online)

KC-AI-14-529-EN-C (print)
ISBN 978-92-79-36144-9 (print)
doi:10.2765/80500 (print)

European Commission

Directorate-General for Economic and Financial Affairs

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Abstract

This work aims to contribute to the policy debate on how to spur "digital growth" in Europe in the context of the crisis, by assessing the potential economic impact of structural reforms efforts either already undertaken or imminently foreseen in the field of European digital markets. Namely, this is done by analysing the growth effect of European reforms in the areas of radio spectrum, professional e-skills, eCommerce, and fixed broadband take-up.

Each policy area is analysed separately, in the first place by hypothesizing and econometrically testing specific "transmission channels", i.e. the direct impact of selected reform variables on intermediate economic outcomes, such as prices and productivity. In the second place, the price and productivity shocks estimated on the basis of the actually observed change in the reform variable (as a proxy for the countries' reform effort) are fed into QUEST III to simulate macroeconomic impacts on GDP. Despite their heterogeneity, the importance of analysing these reforms together lies in the possibility of shedding light on the overall economic impact of fostering specific aspects of the Digital Single Market in the EU.

Indeed, summing up the simulated macroeconomic impacts for different policy areas shows that the long-run growth impact of the already observed digital reform effort is above 1%, and that further efforts in line with the Digital Agenda for Europe targets would entail additional 2.1% of GDP growth over the baseline. From a methodological point of view, the findings highlight the importance to test the adequate functioning of the microeconomic transmission channels through which digital structural reforms could exert their overall macroeconomic impact.

JEL Classification: C33, E17, F15, L51, L96.
Keywords: Radio spectrum, e-skills, eCommerce, broadband, digital markets, productivity, TFP, digital structural reforms, transmission channels, QUEST III.

Corresponding author: Dimitri Lorenzani, Economic Analyst, Directorate-General for Economic and Financial Affairs, European Commission; e-mail: dimitri.lorenzani@ec.europa.eu; phone: +3222971174.

Acknowledgments: This paper presents work carried out in the context of a broader project on the assessment of product market reforms, the main findings of which are presented in the European Commission DG ECFIN report "Market reforms at work in Italy, Spain, Portugal and Greece" (European Economy, 5/2014). Thanks are due for useful comments to Anne Bucher, Isabel Grilo, Werner Roeger, Lucilla Sioli, Gianluca Papa, Josefina Monteagudo, Dominique Simonis, Daria Ciriaci, and the participants to the 12th ZEW Conference on the Economics of Information and Communication Technologies (where the paper was discussed). The views expressed in this paper are the authors' alone and may not be regarded as stating an official position of the European Commission.

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I. INTRODUCTION

There are several reasons for the Member States to undertake ambitious structural reforms in the field of digital markets, even more so in light of the economic crisis. On the one hand, digital structural reforms are part and parcel of the broad policy agenda set by the *Digital Agenda for Europe* (*DAE*, hereafter): this flagship initiative of the Europe 2020 Strategy indicates measures that both the European Commission and the Member States should undertake over 2010-2020 to stimulate the digital economy, address societal challenges through Information and Communication Technologies (*ICT*, hereafter), and allow the Digital Single Market to deliver sustainable economic and social benefits. On the other hand, the economic relevance of electronic communications (*eComms*, hereafter) and, more broadly, of all digital networks and services for which they represent the essential backbone goes well beyond their sectoral size and encompasses positive spill-overs exerted over the whole productive system. ICT is regarded to account for 5% of GDP growth and 20% of productivity growth in Europe ([1]); also, critical ICT infrastructure is crucial to ensure that technological developments and capital deepening can stimulate innovation in SMEs and large industries alike, and eventually translate into productivity gains also in more traditional sectors. Overall, this role as general purpose technology, providing inputs and enablers for several other economic and social activities, makes the price and quality characterizing EU digital markets a crucial policy lever to contribute to a well-functioning internal market, the growth and competitiveness of EU industries, and EU consumers' living standards.

The relevance of the policy debate on how to achieve "digital growth" in the EU, first of all through ambitious digital structural reforms, is witnessed also by the latest annual cycles of European Economic governance, where four Member States in 2013 and one in 2014 received *Country Specific Recommendations* in the field of broadband, by the recently adopted Commission's *Connected Continent* package ([2]) , as well as by the latest "State of the Union" speech ([3]), emphasizing the challenge of fostering a full-fledged European Digital Single Market.

This study aims to contribute to this debate by assessing the potential economic impact of specific digital structural reforms, either already undertaken or imminently foreseen by the EU Member States. This is rather challenging, particularly in a unitary framework, due to a variety of reasons ranging from the marked heterogeneity of these reforms, the "soft" and "indirect" (and thus hardly measurable) nature that they are often bound to take ([4]), as well as the general lack of data on different aspects of EU digital markets. For these reasons, among the disparate reform efforts encompassed by the DAE, only four specific types of digital structural reforms are hereby considered, selected also on the basis of data availability and for their relevance in terms of growth potential, i.e.:

- structural reforms aimed at fostering the deployment of wireless high-speed broadband in the EU, in particular through adequate, competition-enhancing, and investment-enhancing assignments of right of use of radio spectrum frequencies, as foreseen by the Radio Spectrum Policy Programme (RSPP);

- structural reforms aimed at enhancing professional ICT skills in the EU, as addressed also by the Gr*and Coalition on Digital Skills and Jobs*;

([1]) See, for instance, the "European digital competitiveness report, 2010", retrievable at the following URL: http://ec.europa.eu/information_society/newsroom/cf/itemdetail.cfm?item_id=5789.

([2]) The package includes a draft Regulation to achieve a Single Market for Telecommunications and a Recommendation on non-discrimination and cost methodologies. See the *Communication of the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions on the Telecommunications Single Market* - COM(2013) 634.

([3]) Here is the link, respectively, to former President Barroso full speech and his letter to the President of the European Parliament. Namely, the European Commission President not only announced the just approved Commission's proposal for a regulatory package of measures fostering the Single Market for Telecommunications in the EU, but also highlighted the crucial role of the broader digital agenda, which "solves real problems and improves daily life for citizens" as the "strength of Europe's future industrial base depends on how well people and businesses are interconnected".

([4]) For instance, in the case of reforms incentivising e-skills, these are mostly bound to take the form of incentives to training for firms' personnel or general support to ICT teaching in schools.

- structural reforms aimed at deepening the internal market for eCommerce, first and foremost by incentivising the take-up of online sales among firms;

- structural reforms aimed at fostering the deployment of fixed high-speed broadband especially through enhanced investments and easier roll-out, which should contribute to the achievement of the DAE targets of access for all Europeans to fast broadband by 2020 and at least 50% penetration of speeds above 100 Mbps.

On the other hand, given the mentioned heterogeneity of these policy areas, each type of reform is analysed separately, yet following a common twofold methodological approach, which represents also the main value added of this work with respect to previous analyses on the same topic, in particular in light of the close interplay between micro foundations and macroeconomic simulations that characterises it. Namely, as a first step, partial equilibrium econometric analysis – mostly at sectoral level– is carried out, or drawn from existing literature, to estimate the direct impact of the change in a relevant "digital reform indicator" ([5]) on either prices or productivity: these economic outcomes directly affected by the reform effort (proxied by the chosen indicator) are in fact assumed to be the "transmission channels", through which the considered structural reforms can finally exert their overall economic impact. In particular:

- spectrum reforms are found to decrease the retail prices of mobile services, including indirectly through decreased sectoral market concentration;

- enhancing digital skills in a professional setting is found to increase the intra-sectoral allocative efficiency of resources in the economy, likely due to the better capacity of firms to react to changes in the competitive environment;

- increased take up of eCommerce EU-wide is found to affect total factor productivity (TFP), through higher efficiency of the production process entailed by firms' recourse to online sales, and have a price effect due to specificities of online trade;

- increased take-up of high-speed fixed broadband is found to affect TFP by increased efficiency in the production process due to actual firms' use of these technologies.

As a second step, then, the estimated elasticity from the first step and the observed variation of the reform variable, proxying the actual reform effort, are used to compute a price/productivity shock related to the considered digital structural reform effort. Throughout the study, this applies both to reform efforts actually undertaken by the Member States over the observed time period and to further potential efforts related to reaching specific quantitative targets set by the DAE for the coming years.

The final step of the analysis consists in feeding the estimated shocks into the European Commission's dynamic stochastic general equilibrium model *QUEST III*, in order to simulate the corresponding macroeconomic impacts on GDP growth: the conducted analysis, separately for each policy area, allows to add up these long-run GDP impacts and thereby provide a unitary indication of the overall effect of reform efforts in specific areas of the Digital Single Market. Not least, especially in the simulation of the economic impact of further reform efforts in line with the DAE targets, the use of a DSGE model allows to take into account further transmission channels that data availability issues prevent from being econometrically tested, such as the macro impact of specific forms of capital deepening.

This study is organized as follows: Chapter II provides some policy background justifying the presence of already undertaken or imminently foreseen digital structural reforms in the EU; Chapter III features a brief literature review of previous estimations on the impact of digital

([5]) As discussed later on, the choice of these "reform indicators" is among the most delicate parts of the analysis, a caveat of which the authors are perfectly aware. Namely, the underlying objective is to consistently identify an economic variable able to proxy either the actual reform effort already undertaken by the Member States or the further potential effort related to reaching specific quantitative targets set by the DAE for forthcoming years (for instance, assigning a certain amount of spectrum to wireless broadband, ensuring full access to fast broadband by 2020, and having at least one third of SMEs selling online by 2020).

structural reforms; Chapter IV contains, separately for each of the four considered policy areas (spectrum policies in Chapter IV.1, professional e-skills in Chapter IV.2, eCommerce policies in Chapter IV.3, and fixed broadband policies in Chapter IV.4), the methodological details underpinning the estimation of the policy shocks linked to the observed structural reform effort and the related GDP impacts simulated through *QUEST III*. Chapter V concludes and proposes possible areas for further research.

II. POLICY BACKGROUND: WHY ARE DIGITAL STRUCTURAL REFORMS NEEDED?

The *Digital Agenda for Europe* ([6]) was adopted in 2010 as one of the seven flagship initiatives of the Europe 2020 Strategy, with the objective to stimulate the digital economy and address societal challenges through ICT, ideally allowing the Digital Single Market to deliver sustainable economic and social benefits. Electronic communications are the backbone of this ideal EU-wide Digital Single Market. In fact, wider and more effective use of digital technologies, first and foremost broadband Internet, could provide Europeans with a better quality of life through, for example, better health care, safer and more efficient transport solutions, cleaner environment, new media opportunities, and easier access to public services and cultural content.

The DAE Communication listed 101 legislative actions/proposals to be undertaken by the Commission and by Member States by 2020 in a number of policy areas, including: a) reinforcing the Digital Single Market by removing regulatory obstacles that prevent European businesses and citizens from making the fullest possible use of national and cross-border electronic communications services; b) improving ICT standard-settings and enhancing the interoperability of ICT products; c) guaranteeing universal broadband coverage across the European Union with Internet speeds gradually increasing up to fast and ultrafast connections: in particular, it sets the ambitious key performance target, whereby all Europeans should have access to basic broadband (with speed between 144 Kbps and 2 Mbps) by 2013 and to fast broadband (at least 30 Mbps) by 2020, with at least 50% take-up of ultra-fast broadband of 100 Mbps or more; d) fostering ICT-related research and innovation; e) enhancing digital literacy, skills, and inclusion; f) promoting the use of ICT, so as to address the challenges of climate change and of ageing population. Well beyond the eComms sector only, examples of measures meant to achieve a Digital Single Market are: i) the Radio Spectrum Policy Programme, approved in 2012 ([7]); ii) pan-EU licensing for on-line rights management; iii) stronger data protection; iv) updating the eCommerce and e-signature Directives to realise EU-wide e-identification, e-authorization, and online dispute resolution; v) harmonised numbering to enable EU-wide provision of business-services; vi) adequate support to investments in NGA, including LTE wireless broadband.

At the end of 2012, in its "mid-term review Communication" ([8]), the Commission assessed that the DAE had delivered and was broadly on target, with 55 undertaken actions out of the original 101, 36 on schedule for completion by the respective deadline, under the responsibility of either the Commission or the Member States, and 10 delayed or at risk of being delayed. The Communication also set out a renewed commitment to swiftly complete the still pending DAE actions and a refocused agenda encompassing 31 complementary measures to be taken over the period 2013-2015 to better stimulate the digital economy along seven priority fields ([9]).

([6]) Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions: A Digital Agenda for Europe (COM/2010/245 final/2)

([7]) The RSPP aims to ensure sufficient spectrum for mobile broadband by fostering shared use of wireless technologies and freeing additional resources without compromising incumbent license holders' rights. In fact, new technologies allow sharing licence-exempt bands and providing broadband services in "white spaces" in-between TV frequencies, but national regulations mostly fail to reflect them: the Commission thus called for NRAs to monitor and potentially extend the internal market for licence-exempt bands, and foster a consistent EU-wide regulatory approach for shared rights of use.

([8]) European Commission (2012)

([9]) These priority fields include: 1) advancing the European borderless digital economy, creating the world's largest and richest single market for content and services, while fully guaranteeing consumers' and creators' rights; 2) speeding up public sector innovation enabled through the deployment of interoperable ICT and a better exchange and use of information; 3) regaining world leadership for network services, by stimulating private investment in high-speed fixed and mobile broadband networks, enabled by legal predictability, improved planning and targeted private and public EU and national funding; 4) fostering a secure and trustworthy internet environment for users and operators, based on strengthened European and international collaboration in responding to global risks; 5) establishing a coherent framework and conditions for cloud computing services in Europe creating the world's largest cloud-enabled ICT market; 6) creating a favourable environment for transforming traditional business and spurring innovative web-based ventures, and increasing digital literacy and the proliferation of digital skills to fill the gap between demand and supply of ICT professionals; 7) implementing an ambitious strategic research and

Roughly half of the mid-term review new actions have already been undertaken. Overall, this means that different structural reforms in the field of digital markets have been either implemented, or started, or foreseen either at the EU-wide or at a national level. The latest Digital Agenda Scoreboard 2014 ([10]) seems to confirm that some progress has indeed been made in deepening the EU internal market for digital networks and services, not least by pursuing the more integrated EU-wide regulatory: this includes, e.g., increase in regular internet usage, in on-line buying, and in the take-up of high-speed broadband, households' access to fast and ultra-fast internet (so-called NGA networks) growing from below 30% to 64% between 2010 and 2013 ([11]).

However, the data also seem to confirm that a full-fledged internal market for eComms has not been achieved yet, given the existence of still fragmented regulatory regimes, marked "national orientation" of sectoral regulators, including in the assignments of rights of use on radio spectrum, telecom operators essentially confined in their home Member States, and significant differences among Member States in terms of some basic "monitoring indicators". Namely, the magnitude of intra-EU differences for several eComms indicators was shown by the Commission Services ([12]) to be high, especially compared to other network industries like energy and transport, and generally persistent in both price and non-price performance (e.g. coefficients of variation mostly above 30% and an enduring broadband gap), market structure, consumer's choice, and implementation of the regulatory framework. This, coupled with the further evidence of still unsatisfactory shares of cross-border eCommerce and of SMEs selling online in the EU, of lower penetration of high-speed fibre line and more marginal presence of the EU industry in the digital value chain (hardware, software and applications, and OTT services) than US, Japan, and Korea, among the others, indicates that there is significant scope for improvement in terms of deepening the Digital Single Market through ambitious structural reforms.

innovation policy for industrial competitiveness based on funding key enabling technologies.

([10]) See the *Digital Agenda Scoreboard 2014* at http://ec.europa.eu/digital-agenda/en/download-scoreboard-reports

([11]) See *Europe's Digital Challenge* – Commission contribution to the European Council of 24-25 October 2013. However, one should take into account that comparisons between the EU and the rest of the world should be made with caution, in consideration of the different quality of the respective e-communication networks and of the country-specific conditions hindering or fostering their development over time.

([12]) See Maincent E. et al. (2013).

III. LITTERATURE REVIEW

Several works aimed to assess the economic impact of structural reforms in the field of digital networks and services. However, given the diversity of reforms that are encompassed by this label, the existing literature is also characterised by a variety of approaches to addressing the various issues surrounding the assessment of each type of reform. Therefore this Chapter briefly outlines first existing estimations tackling broadly defined digital structural reforms or multiple policy areas, and, in the second place, the literature on the specific policy fields analysed in this study, respectively spectrum allocation, professional ICT skills, eCommerce, and broadband.

Among the **works assessing the general impact of broadly defined digital structural reforms**: Copenhagen Economics (2010) contains a valuable reference to the productivity impact of sectoral reallocation, largely recognized as a crucial transmission channel related to measures affecting not only ICT capital (i.e. investments) but also ICT usage; however, the estimated impacts sometimes appear not to be fully supported by empirical evidence, making it hard to rely on them for specific measures. Overall, it is estimated that overcoming country-specific fragmentation and reaching a full-fledged competitive Digital Single Market would imply a gain of 4% of GDP at EU level over 2010-2020. This calculation is based on a two-step approach, partly derived from MICUS (2009): the first step estimates a positive impact by 3% p.a. of improved physical infrastructure and improved e-readiness on the take-up of online services. This in turn is assumed to lead to a structural change in the EU economy, reallocating resources from the rest of the economy towards business services: since their productivity is relatively high, and assumed to be further boosted by 0.2% due to online services take-up, this entails a GDP increase by some €5.7bn per year. In terms of increased competition in the internal market for electronic communications networks and services, on the other hand, a study conducted by Ecorys (2011) for the European Commission estimates an economic impact from deepening the Telecoms Single Market between 0.5% and 0.9% of GDP per year, thanks to higher efficiencies generated by more competitive markets and economies of scale ([13]).

Among the **works assessing the impact of specific digital structural reforms**, thereby focussing on narrower aspects of European digital market -such as spectrum assignment, e-skills, eCommerce, and broadband investment and use-, yet closely intertwined with the broader achievement of a Digital Single Market, the following could be mentioned:

- there is scant available literature on the economic effect of **spectrum auctioning**, with the exception of analytical works focussing on the efficiency of different auction designs, like Klemperer (2002) and Plott and Salmon (2004); also, the few studies analysing the socio-economic impact of spectrum allocation either fail to present a full-fledged econometric analysis or are very country-specific, as in Hazlett et al. (2007), Prasad and Sridhar (2009), and GSM (2013); Tiedemann (2009) provides regression analysis on the impact of spectrum auctioning, although for the case of Canada. In any case, most of these studies seem to suggest that management regimes ensuring liberalized and abundant spectrum availability tend to be associated to lower transaction costs, higher competition, correspondingly lower retail prices and higher rates of output (minutes of use).

- A vast literature supports the theoretical intuition that use of ICT by the labour force, allowed by adequate **e-skills**, affects the productivity of the economic system, first and foremost through capital deepening, enhanced workers' efficiency, and facilitated product and process innovation. For instance, long-standing findings on the contribution of ICT capital and ICT use to output and labour productivity growth can be found in Black and Lynch

([13]) The study calculates the weighted average HHI or market shares in the EU in the respective base year (weighted against population). Next it determines the weighted average values of the other variables in the regression functions. Using the regression functions, it calculates the average level of performance in the EU (in terms of ARPU and investments). It then assumes that all Member States (and thus the EU average) move towards the best performing country in terms of HHI or market share of new entrants.

(2001), Pilat (2002), Van Ark et al. (2003), Eurostat (2008). In terms of the transmission channels through which the impact of ICT on the economy takes place, an interesting line of research emphasizes the role of resources reallocation: Pilat (2004) and Bartelsmann (2013) argue that turning investment in ICT into higher productivity requires complementary investments and changes, first of all in human capital, organisation and innovation, due to a "process of search and experimentation, where some firms succeed and grow and others fail and disappear". Also more recent literature focuses on the role of human capital in this productivity-enhancing process: for instance, Hagsten and Sabadash (2013) find that the proportion of ICT-intensive human capital in firms has a positive impact on firm productivity, and Goos M. at al. (2013) highlight the growth potential of "high-tech workers", employed in high-tech and STEM (science, technology, engineering, and mathematics) sectors.

- In terms of structural reforms deepening the EU internal market for **eCommerce**, the existing literature seems to identify two main transmission channels through which their economic impact takes place. On the one hand, some literature empirically investigated the theoretical *efficiency effect* whereby firms' higher recourse to e-trade could in turn improve their productivity (growth), also due to the effect of organisational learning, flexibility, and adoption of innovative practices: namely, Eurostat (2008) and Hagsten (2013) investigate to what extent ICT use has an impact on productivity over and above the physical availability of ICT infrastructure, by carrying out regression analysis, both at firms and sectoral level ([14]), on the productivity impact of two metrics of ICT use: i) eCommerce intensity, measured by the proportion of firms' trade undertaken through electronic mediums, like the Internet; ii) the proportion of firms' workforce with access to high-speed Internet. The underlying econometric model is an augmented standard production function:

$$\ln\left(\frac{Y}{L}\right)_{it} = a_1 EC_{it} + a_2 BB_{it} + a_3 \ln\left(\frac{K^R}{L}\right)_{it} + a_4 \ln\left(\frac{K^I}{L}\right)_{it} + a_5 \ln \overline{E}_{it} + a_6 X_{it} + a_7 D_t + a_8 D_s + \varepsilon_{it} + \omega_i \quad (1)$$

where EC and BB are the mentioned metrics of ICT use (eCommerce and broadband, respectively), K^I is the ICT capital controlled for, K^R is the non-ICT capital, L indicates labour, X is a vector of control variables including ICT maturity and skills (proxied by the log-wage costs per employee), D is a vector of year and sector dummies controlling, respectively, for time-specific shocks and sectoral features like different technological intensity across sectors. Overall, the analysis shows a significant positive correlation between ICT use and total factor productivity (TFP), although *caveats* to be taken into account are: i) the sometimes marked discrepancies in estimated coefficients among Member States, possibly justified by country-specific structural differences in ICT use (which means that the estimates should converge as the countries evolve towards the same level of ICT-maturity); ii) the focus on only 13 Member States, and particularly on NL and UK because of the availability of firm-level data on ICT capital (allowing to test the impact of ICT use over and above that of ICT capital services in productivity models). Graph III.1 below reports the regression output for Dutch TFP (growth) at sectoral and economy-wide level: the findings indicate that eCommerce take-up tends to have a consistently significant and positive impact on productivity, including when ICT capital and skills are controlled for ([15]).

([14]) It is worth noting that, within the project, the two levels of analysis are closely intertwined, as it is based on the construction of distributed micro-data datasets (DMD), i.e. a metadata warehouse, used to weight and aggregate ICT use, structural business and business register data from surveys in all 13 countries under scrutiny in a reasonably comparable way; the aggregation process, returning estimates of complex indicators (constructed from more than one survey variable) can be used for industry/country level analysis and to generate datasets on a highly comparable basis for firm level regression analysis within countries.

([15]) Still, there are sectoral specificities, for instance the fact that the largest impact on productivity is related to eCommerce intensity among firms selling in distribution services, while in other sectors, mainly business and financial services, the largest productivity impact over the first half of the 2000s comes rather from the workers' access to broadband.

Graph III.1: **Sectoral and economy-wide regression output for NL (based on firm-level data)**

	(1)	(2)	(3)	(4)	(5)	(6)
Sample	Whole Economy	Whole Economy	Whole Economy	Production	Distribution Services	Differentiated Services
Total Capital	0.147					
	(0.007)***					
Non IT Capital		0.082	0.122	0.066	0.06	0.125
		(0.006)***	(0.007)***	(0.008)***	(0.012)***	(0.012)***
Labour	0.012	0.023	0.031	0.046	0.017	0.0001
	(0.005)**	(0.006)***	(0.007)***	(0.008)***	(0.011)	(0.011)
IT Capital		0.0001	0.046	-0.003	-0.012	0.005
		(0.005)	(0.006)***	(0.008)	(0.01)	(0.014)
% of Employees using Broadband Computers	0.063	0.082	0.253	0.042	0.03	0.131
	(0.026)**	(0.027)***	(0.031)***	(0.043)	(0.047)	(0.047)***
% e-sales (intensity)	0.148	0.165	0.153	0.045	0.27	0.054
	(0.042)***	(0.043)***	(0.050)***	(0.057)	(0.065)***	(0.163)***
% e-procurement (intensity)	-0.001	0.007	0.323	0.126	-0.016	-0.078
	(0.043)	(0.044)	(0.052)	(0.09)	(0.051)	(0.098)
ICT Maturity	(+)*	(+)*	(+)**	Yes	(+)**	Yes
log (wages)	Yes	Yes	No	Yes	Yes	Yes
Observations	3852	3852	3852	2426	730	696
R-squared	0.52	0.5	0.32	0.41	0.55	0.69
SIC2 and Time - Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes

Source: Eurostat (2008)

On the other hand, some literature empirically investigated the theoretical *competition effect* of eCommerce, whereby its increased take-up should lead to more competition, due to higher quantities of online trade, generally characterized by lower and less dispersed observed prices. Civit Consulting (2011), indeed, finds online prices to be, on average, 2.6% lower than offline ones, based on a December 2010 database of 4559 observations of online-offline price differences in 17 Member States for 7 categories of final goods: on this basis, it is estimated that achieving full integration of the EU internal market for eCommerce would decrease average online prices by 21% EU-wide, thanks to the possibility of EU consumers to freely resort to cross-border online purchases, rationally at the lowest available online price EU-wide (excluding delivery costs). Duch-Brown and Martens (2014) also investigated price differences between EU online and offline retail channels, based on a large dataset of online and offline prices of household appliances in 21 Member States in 2009: the evidence shows lower and less dispersed online prices, more price-elastic online demand, and a potential estimated gain in terms of consumer surplus of 0.02% of EU-27 GDP from full online price convergence across the EU towards the lowest observed average price.

- A vast amount of literature has, including recently, investigated the impact of achieving the specific objective of **bridging the broadband gap** among Member States, closely intertwined with that of deepening the Digital Single Market; namely, most literature has focussed on the economic benefits entailed by (physical) availability of broadband, as opposed to its actual use and take-up. For instance, it is estimated by Czernich et al. (2009), based on a panel of OECD countries over 1996-2007, that a 10 p.p. increase in broadband penetration could raise annual per-capita growth by 0.9-1.5 p.p. ([16]). Fuhr and Pociask (2007), Davidson and Santorelli (2009), McKinsey Global Energy and

([16]) However, it should be taken into account that the mentioned study investigates the impact of *basic* broadband, based on the OECD definition of speed ranges above 144 kbps. Therefore, in the current phase of network upgrade from basic broadband to NGA networks, one should reasonably expect the overall impact to be lower.

Materials (2009), and Greenstein S. and McDevitt (2011) also analyse in a more qualitative way the benefits of broadband investments, including social (e.g. reduced isolations of regions and individuals), economic (e.g. net job creation), and environmental (e.g. reduced carbon emissions) ones. In Analysys Mason and Tech4i2 (2013) the socio-economic spill-overs of high-speed broadband investments in the EU are estimated on the basis of a scenario analysis underpinning consumer surplus calculations and input-output analysis based on multiplier effects (i.e. the growth impact that investments in one sector can induce in all others). Whereas an ambitious scenario includes also a large-scale public investment in infrastructure deployment to achieve the DAE targets (see Chapter II), a modest scenario encompasses "*a conservative estimate of the impact of some softer policy measures considered by the Commission, like broadband mapping, infrastructure registration and sharing, co-investment measures, streamlined admin and standards development*". The results of the analysis, referred to the EU27, are the following: i) in the modest scenario the additional consumer surplus over the baseline ('do nothing') amounts to €2.1bn, including €26.3bn additional investments in NGAs, and the additional input-output benefits to €89.2bn (i.e. around 0.7% of GDP growth); ii) in the ambitious scenario the additional consumer surplus over the baseline amounts to 5.4bn€, including €134.8bn additional investments in NGAs, and the additional input-output benefits to €388.2bn (i.e. around 3% of GDP growth). However, as suggested in Eurostat (2008), Eurostat (2012) and Hagsten (2013) ([17]), infrastructural deployment is a necessary condition but not a sufficient one for broadband availability to exert its full economic impact: indeed, the aforementioned empirical findings suggest that the "ultimate cause" of TFP growth (after capital deepening is taken into account) include ICT use, also of broadband. Namely, undertaken firm-level econometric analysis indicates a positive impact on productivity of higher use of high-speed broadband, particularly by workers and over and above the mere availability of ICT infrastructure ([18]). In fact, the use of fast Internet may capture unmeasured software and knowledge management by employees, more open and flexible working methods, or anyhow broader knowledge-capital deepening, playing an integral role as an innovation input, which is economically expected to have a mediated impact on overall TFP. Also, this impact should capture, well beyond "within-firm" productivity effects, the reallocation of resources taking place within industries due to differential growth, and to firms' entry and exit. In other words, this responds to the intuition that ICT adoption is somehow positively associated with the dynamism of the market, i.e. the ability of ICT users to grow within their markets (and contribute to market expansion) and to take market shares off less successful firms.

([17]) Up-to-date estimates are drawn from Hagsten (2013). The used specification also includes variables for capital, employment, wages (proxy for human capital) as well as controls for affiliation, international experience, size class, industry and time.

([18]) For some further evidence on this, see Acreo Swedish ICT (2013), whose summary can be retrieved at https://www.acreo.se/sites/default/files/pub/acreo.se/EXPERTISE/broadband/socio-economic_return_of_stokab_investment_twocolumns_notjustify.pdf.

IV. MAIN FINDINGS

With respect to previous estimations in the literature, outlined in Chapter III, the value added of the present analysis consists in the adoption of a twofold approach, characterised by a close interplay between micro foundations and macroeconomic simulations, to assessing the impact of already undertaken or imminently foreseen digital structural reforms in the fields of radio spectrum, e-skills, eCommerce, and broadband in the EU ([19]). This methodology is consistently applied to all these types of reform areas, although they are presented separately in the rest of this Chapter (namely, radio spectrum reforms in Chapter IV.1, e-skills reforms in Chapter IV.2, policies to deepen the internal marker for eCommerce in Chapter IV.3, and reforms enhancing broadband deployment and use in Chapter IV.4) due to the marked heterogeneity of their nature.

In the first step of this approach, partial equilibrium econometric analysis –mostly at sectoral level– is carried out, or drawn from existing literature, to estimate the direct impact of the change in a relevant "digital reform indicator" (measuring the reform effort for each of the analysed policy areas) on either prices or productivity. In fact, these economic outcomes, directly affected by the reform effort, are assumed to be the "transmission channels", through which the considered structural reforms can exert their overall economic impact. In summary (for the details please refer to the following subsections):

- spectrum reforms are found to decrease the retail prices of mobile services, including indirectly through decreased sectoral market concentration;
- enhancing digital skills in a professional setting is found to increase the intra-sectoral allocative efficiency of resources in the economy, likely due to the better capacity of firms to react to changes in the competitive environment;
- increased take-up of eCommerce within the EU internal market is found to affect total factor productivity (TFP), through higher efficiency of the production process entailed by firms' recourse to online sales, and have a price effect due to some specificities of online trade;
- increased take-up of high-speed fixed broadband is found to affect TFP by increased efficiency in the production process due to actual firms' use of these technologies.

As a second step of the adopted approach, then, the estimated elasticity from the first step and the observed variation of the reform variable, proxying the actual reform effort, are used to compute a price/productivity shock related to the considered digital structural reform effort. Throughout the study, this applies both to reform efforts actually undertaken by the Member States over the observed time period and to further potential efforts related to reaching specific quantitative targets set by the DAE for the coming years. The final step of the analysis consists in feeding the estimated shocks into the European Commission's dynamic stochastic general equilibrium model *QUEST III*, in order to simulate the corresponding macroeconomic impacts on GDP growth. The simulation is based on the 27+1 region version of the *QUEST III* model with R&D and skills extension ([20]), as described in Annex 1. Besides, and particularly in the context of the simulation of the economic impact of future reform efforts in line with the DAE targets, the use of *QUEST III* allows to simulate also the effect of the considered reforms, conveyed through additional transmission channels that data availability issues prevent from being econometrically tested. In particular, this is the case for the externality effect on private investments of the public capital deepening, due to higher and more efficient spectrum availability and due to additional broadband investment.

This analysis, undertaken separately for each of the four policy areas, finally allows to add up the simulated long-run GDP impacts, and thereby provide a unitary indication of the overall effect of reform efforts in specific areas of the Digital Single Market. Graph IV.1 below summarises, for each of the specific reforms analysed in detail in the rest of the Chapter, the identified transmission

([19]) Operational needs and data limitations suggest to focus on specific digital structural reforms, representing only a narrow subset of all measures in the DAE, in order to restrict the scope of the analysis and allow for more realistic modelling assumptions.

([20]) For details, see Roeger et al. (2008) and Varga and in 't Veld (2011).

channel(s), the outcome variable(s) found to be directly affected by them, the type of shock(s) fed into *QUEST III*, and the simulated long-run impact(s) on EU GDP.

An important *caveat* to be borne in mind is that measuring the economic impact of digital structural reforms is partly hindered, on the one hand, by the difficulty to adequately proxy the actual reform effort on the basis of the change over time in a "reform indicator", on the other by the factual impossibility of a direct translation of various ICT services into an explicit monetary value to be incorporated into the model (e.g. open-source application and services including free email accounts, browser search, and Wikipedia) ([21]). Another aspect that the adopted approach is unable to capture consists in the increase in the quality of the e-shopping experience within a deeper Digital Single Market due to, for instance, to higher product variety within a borderless e-market. A way forward to quantify these economic benefits would be to estimate the additional consumer surplus stemming from the use of ICT services or to e-product variety, for instance by asking consumers to assign a monetary value to it, as in McKinsey & Co. (2010). An example of this approach is hereby provided only in the specific case of eCommerce (see Section IV.3), by estimating the impact on consumer surplus of the actual increase in the relevance of online retailing across Member States, essentially due to price effects. However, since a broader assessment of this type of impacts is beyond the scope of this exercise, its findings should be regarded as lower-bound estimates of the potential economic impact of already undertaken digital structural reform or of reaching further DAE-related policy targets.

([21]) One should also take into account that mediated impacts of the measures under scrutiny, like the opportunity cost of the time saved thanks to the adoption of NGA technologies, e.g. insofar as they allow the use and diffusion of e-Government and e-Health services, are not factored in the model either.

Graph IV.1: **Summary table of reform areas, tested transmission channels and direct economic impact**

Structural Reform area	Economic outcome variable directly affected	Transmission channels tested through econometric analysis	Partial equilibrium estimation of observed policy changes in EU27	Simulated GDP impact (already achieved from actually observed effort)	Simulated GDP impact of closing the gap with the Digital Agenda for Europe targets
Assigning Radio Spectrum Frequencies	Final retail price of mobile voice services	Impact of increased assignment of radio spectrum frequencies on sectoral retail prices, both direct (through innovation) and indirect (through reduced market concentration)	Average decrease in sectoral prices between 21% and 22% EU-wide due to observed spectrum progress between 2007 and 2013	0.2% long-run	0.3% - 0.4% long-run
	Capital deepening	Only simulated through QUEST: leverage effect on private capital of deepened public capital due to spectrum revenues, and efficiency effects due to measures reducing deployment costs	N.A.	N.A.	
Enhancing professional e-skills	Intra sectoral allocative efficiency	Impact of increased sectoral share of ICT skilled employment on allocative efficiency	0.65 p.p. average increase in sectoral allocative efficiency (and close to 0.5 p.p. increase in labour productivity) EU-wide	0.6% long-run	0.4% long-run
Reinforcing the integration of the Digital Single Market and e-business models	Total factor productivity and final prices (mark-ups and consumer surplus)	Impact of increased recourse to e-sales among firms on productivity and impact on consumer surplus of higher recourse to e-sales (through a competition effect).	Average increase in TFP by 0.07% over 2010-2012 and increase in consumer surplus by 1.3% GDP p.a. over 2009-2012	0.1% long-run (plus the impact on consumer surplus)	1.9% long-run
Incentivizing fixed broadband deployment	Total factor productivity	Impact of increased use of broadband technologies in a professional setting on firm-level productivity and thereby on TFP	TFP increase by 0.17% due to more broadband take-up among workers	0.2% long-run	0.43% long-run
	Capital deepening	Only simulated through QUEST: externality effects of private capital increase due to public incentives and efficiency effects due to measures reducing deployment costs	N.A.	N.A.	

Source: Own calculations

IV.1. THE ECONOMIC IMPACT OF RADIO SPECTRUM POLICIES ([22])

Electromagnetic waves in the frequency range below 300 GHz, also called *radio spectrum*, are an indispensable input for different technologies, including specific mobile communications services. Radio spectrum can be considered a public good, as its different parts are allocated by competent national authorities (governments or regulators) to different transmission technologies and applications and, especially in the case of mobile communications or broadcasting services, sold or licensed to private operators of radio transmission services ([23]). At the EU level, the

([22]) Thanks are due to Agozzino Emanuela, Savelli Caterina, Viallon Maxence, and Zorenyi Balazs for providing technical support to build the employed dataset, as well as for commenting on this Section.

([23]) Because of the potential electromagnetic interference between users, the generation of radio waves is strictly

Box IV.1: THE EU REGULATORY FRAMEWORK FOR SPECTRUM

The *EU Regulatory Framework* for electronic communications networks and services, among different amendments to the 2002 "Second Telecoms Package", put emphasis on the strategic planning and coordination of radio spectrum policies. In fact, whereas spectrum management remains among the Member States' competences, a coordinated and strategic approach and, where appropriate, harmonisation at Community level could help ensure that spectrum users derive the full benefits of the internal market and that EU interests could be effectively defended globally.

This more coordinated regulatory approach to spectrum was reflected by the May 2010 *Digital Agenda for Europe*, indicating a EU-wide *Radio Spectrum Policy Programme* (RSPP) among the ambitious measures to pursue in order to achieve a Digital Single Market. The RSPP covers all types of radio spectrum use that affect the internal market and sets general regulatory principles, policy objectives and priorities, with the aim to enhance efficiency and flexibility in spectrum use, as well as preserving and promoting competition without compromising incumbent licence holders' rights. By supporting specific spectrum needs (such as for wireless broadband communications, transport, environment protection, Earth surface monitoring or research and space exploration), the RSPP objectives are rooted in the overall goals of the EU's Radio Spectrum Policy.

In particular the Commission and Member States collaborate for the achievement of concrete actions to meet RSPP objectives: setting up a spectrum inventory, ensuring that at least 1200MHz of spectrum are identified to meet the needs of growing wireless traffic, allowing spectrum trading and fostering spectrum sharing, and ensure that spectrum can support other European policies such as energy efficiency. Overall, freeing significant spectrum resources for electronic communication services in the Member States could make a major contribution also to the spread of mobile broadband networks, in line with the *Digital Agenda* penetration targets. In particular, Member States have adapted and coordinated their national provisions in order to take into account: i) the opening of the 800MHz band to wireless broadband by January 2013 by switching from analogue to digital broadcasting; ii) the on-going *refarming* exercise of the 900MHz band once reserved to GSM to open it to other systems capable of providing advanced mobile services which are compatible with existing GSM use, particularly UMTS. In particular, among all harmonisation measures, the assignment of the so-called digital dividend, i.e. the 800MHz band freed by the switching off of analogue emissions mandated by 2012, has attracted particular policy interest.

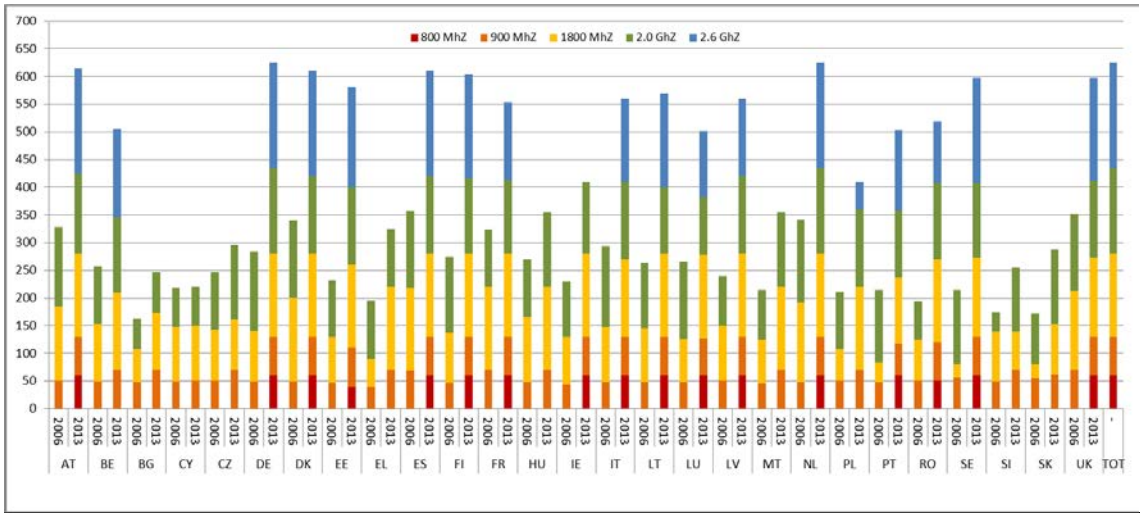
2009 *Third Telecoms Package* and the 2010 *Digital Agenda for Europe* define a clear policy framework for a wide and efficient allocation of radio spectrum to mobile communication providers (see Box IV.1) ([24]).

Therefore, spectrum policies allocating spectrum bands to market operators have been among the major structural reforms undertaken by the Member States in the field of digital markets and services, including during the crisis. In fact, the *Radio Spectrum Policy Programme* foresees the assignment of at least 1200MHz of spectrum to broadband communications: several assignments have thus been recently completed or foreseen in all Member States, making frequencies below and above 1GHz available to operators, often at the same time (multiband assignments). This reform effort, referred to the period between 2006 and 2013 and to harmonised bands between 800MHz and 2.6HGz, is evident from Graph IV.2 below.

regulated by the government in most countries, coordinated by an international standards body called the International Telecommunications Union (ITU).

([24]) The box is based on Maincent et al. (2013).

Graph IV.2: **Evolution between 2006 and 2013 in the assigned spectrum across five relevant harmonised bands in the EU27**



Source: Commission Services and own calculations

IV.1.1. Identified transmission channels and partial-equilibrium results

This Section aims to assess the potential economic impact of making spectrum frequencies available to mobile operators in the EU, by laying emphasis on the "transmission channel" of this impact, i.e. the actual economic process whereby this reform is assumed to affect the whole economic system. Namely, in line with the scant literature reviewed in Chapter III, the assumption tested in this Section is that spectrum auctioning could affect sectoral retail prices, namely reducing them, through two simultaneous channels: i) on the one hand, *indirectly*, through a competition effect; ii) on the other hand, *directly*, over a sufficient timeframe, through an innovation effect. The first (indirect) effect is theoretically justified by the fact that spectrum auctioning could affect sectoral market concentration, which in turn is relevant in explaining sectoral equilibrium prices: indeed, the experience of spectrum auctioning across the EU indicates that NRAs often foresee "reserved" spectrum blocks, explicitly meant to allow the entry of new providers, or attach "competition-enhancing conditions" to the granted rights of use, pursuant to the EU Framework. This could be expected to reduce market concentration in a relatively modest timeframe, and in turn affect prices in a mediated way over a more extended period. For the second (direct) impact, instead, a possible explanation is that new bands are typically auctioned to allow the roll-out of new (once 3G, now 4G) technologies, whose diffusion and uptake could reduce the equilibrium price of services provided over older technologies (e.g. 2G) also by means of demand-side effects.

To test this hypothesis, econometric analysis is carried out on a panel dataset covering all 27 Member States and years between 2006 and 2013 ([25]). The dataset has been constructed on the basis of the European Commission's *Digital Agenda Scoreboard* and of the *European Communications Office*'s data, sources providing reliable and cross-country comparable sectoral information.

Each country's structural reform effort in making frequencies available to mobile operators is proxied by an original index of national cumulative progress in spectrum assignment (relative to the overall quantity available, in MHz). This has been computed for each Member State as the weighted average of band-specific cumulative proportions of assigned spectrum, relative to the total amount available, in five harmonised bands

([25]) Please note that data on the spectrum index are available from 2006 to 2013, and for the Herfindahl index from 2006 to 2012 but the scope of the dataset is limited by the fact that observation for the main dependent variable of the analysis, i.e. the average mobile retail price, are available only from 2007 to 2011. Besides, the reporting of this variable in the *Digital Agenda Scoreboard* has been discontinued since the 2014 issue.

relevant for mobile communications (800MHz, 900MHz, 1.8GHz, 2GHz, and 2.6 GHz) ([26]). Therefore, in each year, changes in this index correspond to the Member States' marginal progress in assigning rights of use on spectrum to market operators, thereby proxying their yearly "reform effort" in this field ([27]).

Other variables assumed to be directly or indirectly influenced by spectrum assignments are: i) a quasi-Herfindahl index (*HHI*) of sectoral market concentration ([28]): this varies from 0 to 1, which indicates highest concentration, and provides a close approximation of the actual concentration in national mobile markets at the end of each year, accounting for both the number of operators and their market power (based on *Digital Agenda Scoreboard* data); ii) the average sectoral retail price per minute, defined, in the *Digital Agenda Scoreboard*, as the ratio of total mobile voice revenues to total outgoing retail minutes of voice communication over the whole year under scrutiny ([29]). It is worth remarking that this price indicator refers to voice services and thus excludes data ones, representing a growing share of operators' revenues as well as more likely to be affected by spectrum assignments: however, the fact that voice services still represented some 63% of operators' revenues in 2012 (in downward trend from the past), and the marked difficulty of constructing a reliable time series for a complementary price indicator including also data traffic, both seem to justify the use the voice revenue per minute indicator ([30]).

The econometric methodology used to test the hypothesised transmission channels is the following two-step approach: in a first step, the impact of spectrum assignment (measured by the constructed indicator) over market concentration is estimated. A second step then estimates the impact on retail prices of both spectrum assignment and predicted market concentration, based on the first step. This 2SLS/IV approach thus corresponds to estimating together the two following equations, considering market concentration as endogenous, as jointly explained by spectrum progress together with prices, by instrumenting it with spectrum progress itself:

$$HHI_{it} = a_1 + a_2 I(spectrum)_{it} + a_4 X_{it} + a_5 D_t + \varepsilon_{it} + \omega_i \quad (2)$$

$$P_{it} = b_1 + b_2 L.I(spectrum)_{it} + b_3 L.HHI^*_{it} + b_4 Y_{it} + b_5 D_t + \varepsilon_{it} + \omega_i \quad (3)$$

where *HHI* indicates sectoral concentration, *P* the sectoral prices, I(*spectrum*) the constructed index of spectrum compliance, *L.* the first lag of a variable ([31]), X_{it} and Y_{it} two vectors of control

([26]) Please note that the 3.4 and 3.6 GHz bands have been so far deliberately excluded both due to the lack of reliable information to build the index, and for the relatively smaller effort and progress related to them across Member States. The weights to build the index are proportional to the EU-wide average unit price of each spectrum band, based on the actual auction prices observed EU-wide over 2008-2013: indeed, this can be assumed to reflect the quality and scarcity, and thus relevance for competition, of licenced spectrum.

([27]) It is also worth noting that building a composite cross-band indicator also increases the efficiency of the estimates, given the limited sample size. A natural extension of the analysis as more data become available would thus be to consider each harmonised band separately, in order to have band-specific efforts and related economic impacts.

([28]) This is computed on the basis of the observed market shares of the main mobile operator and its main competitor, based on the DAS2013, and assigning the residual market share half to the other active mobile network operators (MNOs) and half to the mobile virtual network operators (MVNOs). This hypothesis on the tail of the distribution has been subject to a robustness check, by changing the proportions to 2/3 (and 1/3) and 1/3 (and 2/3), respectively: the results, substantially analogous to those obtained under the “main” hypothesis, are available upon request.

([29]) It is worth noting that the "average price per minute of voice communication" (APPM) was defined until 2009 as the ratio of total mobile voice revenues to total outgoing minutes of voice communication (excluding VAT but including access charges), while, as from 2010, the average revenue per minute of voice communications (ARPM) considers the ratio of all retail voice-related revenues to total outgoing retail voice minutes regardless of the call types (which can make a difference, e.g. in the widespread presence of bundled offers). A slight adjustment allows to make use of the whole time series for sectoral prices.

([30]) Overall, this analysis also suggests that the time is ripe to reflect more seriously on how to build a new price indicator including also data, which is currently missing at the EU level. So far, to compare prices of voice and data services, one has to follow the OECD methodology, using typical consumption baskets available only for OECD countries, so not for all EU28. The best solution would be a price per minute but, as a first approximation, one could to take the total mobile revenue, divide it by the population, and correct this ratio by the observed penetration of subscriptions: this would allow having not just a revenue per subscription (ARPU), highly influenced by differences in usage (as each user could have more than one SIM card), but a revenue per subscriber, indicating the average spending per user independently of how the usage is organized.

([31]) The choice to lag the relevant explanatory variables is justified by two reasons: i) from a statistical viewpoint, the sectoral retail price is an average computed on the basis of all offers of a year, while concentration and spectrum progress are point data in October and June of that year, respectively: a lag structure thus offsets the problem that

variables drawn from *Eurostat* and the *Digital Agenda Scoreboard*, D_{it} time dummies included to control for common cyclical or regulatory shocks, and ω_i fixed-effects in panel specifications for country-specific time-invariant factors. Control variables in Y_{it} include, in line with Tiedemann (2009), the percentage of population living in rural areas, a proxy for the cost of providing the service, which goes up as the population is more sparse; control variables in X_{it} include the penetration of mobile subscriptions and the wholesale cost of mobile number portability, approximating competitive conditions in the mobile communications market. The reported values of the Kleibergen-Paap LM test (on under-identification of parameters) and the Hansen J test (on over-identifying restrictions) all hint at the goodness of the chosen instruments and the identification of the estimated IV model. It is worth noting that all variables in (2) and (3) are taken in first differences to avoid risks of spurious regressions due to the fact that there is an overall tendency for spectrum compliance to increase and for prices and market concentration to decrease over time, e.g. as an effect of subsequent waves of competition-enhancing ex-ante regulation; also, the statistically significant evidence ([32]) that all three series are integrated of order 1 further supports this choice to differentiate.

It is worth noting that estimating the equations (2) and (3) together gives *de facto* an estimation of both the direct effect of spectrum progress on retail prices and its indirect impact channelled through market concentration ([33]). Table IV.1 below reports the estimates obtained for equation (2) under alternative specifications and regression methods, among which a generalized Hausman-type test indicates a preference for a fixed-effects model ([34]). Overall, the reported findings consistently indicate a statistically significant negative relationship between progress in spectrum licencing and variations in the concentration of the mobile communications market, for instance due to more active operators or reduced relative market power: namely, a 10 p.p. increase in spectrum compliance is found to reduce market concentration by between 0.4 and 0.44 p.p. The fact that the lagged progress in spectrum licencing is not statistically significant supports the hypothesis that the impact on concentration operates mostly in the short term, for instance through NRAs reserving bands to new entrants. All coefficients attached to the control variables have the expected sign: the penetration of mobile subscriptions has a significant negative effect, in line with the intuition that market expansion creates new opportunities for new entrants, and portability cost, approximating wholesale level obstacles to switching and thus to competition, has a positive impact, in line with the intuition that market power increases as switching becomes less straightforward.

the dependent variable would be otherwise at least partly subsequent to the independent ones; ii) from an economic viewpoint, a certain time is assumed for the transmission channel to work, in line with economic intuition and a vast literature explaining prices with lags. Unfortunately, data limitations have prevented us from testing a different lag structure, which is a caveat to be taken into account in reading results.

([32]) Based on the Harris–Tzavalis unit root test of for panel data, suitable for short panels, as it assumes that the number of panels tends to infinity while the number of time periods is fixed. We are aware that a more rigorous analysis, unfortunately prevented here by data limitations, should have actually investigated whether the variables of interest are cointegrated: this approach should thus be considered as a second best and cointegration analysis as a natural extension once more data become available.

([33]) Our identification strategy lies on the hypothesis that the spectrum index *I* is exogenous with respect to the dependent variables, as it is a policy lever whose use has typically relied in the past on different reasons than market price or concentration. Since the more recent approach encompassed by the (still draft) Telecoms Single Market Regulation lays more emphasis on the role of competition, this methodological choice could be improved on in future research.

([34]) Sargan-Hansen test statistic 27.077 (p-val = 0.0003)

Table IV.1: **Determinants of (first difference) HHI - effect of progress in spectrum auctioning**

VARIABLES (first differences)	HHI					
	(a)	(b)	(c)	(d)	(e)	(f)
	FE	RE	FE	RE	FE	RE
Progress in spectrum auctioning	-0.0404***	-0.0277**	-0.0395***	-0.0230*	-0.0441***	-0.0258*
	(-0.0115)	(-0.0111)	(-0.0136)	(-0.0138)	(-0.0145)	(-0.0144)
Progress in spectrum auctioning (lagged)			-0.0306	0.00511	-0.03	0.0069
			(-0.0264)	(-0.0296)	(-0.0264)	(-0.029)
Penetration rate of mobile subscriptions	-0.144***	-0.122***	-0.170***	-0.131***	-0.166***	-0.128***
	(-0.0331)	(-0.0326)	(-0.0262)	(-0.0313)	(-0.0268)	(-0.0325)
Wholesale cost of mobile portability					0.00113**	0.00105**
					(-0.0005)	(-0.0005)
Year dummies	yes	yes	yes	yes	yes	yes
Observations	162	162	135	135	135	135
R-squared	0.212	0.1565	0.24	0.1688	0.261	0.187
Number of countries	27	27	27	27	27	27

(1) Robust standard errors in parentheses.
Constant term included. * significant at 10%; ** significant at 5%; *** significant at 1%
Source: Own calculations

Table IV.2 below reports the reports estimates obtained for equations (2) and (3) through the mentioned instrumental variable approach: the second step explains changes in the mobile retail price with the marginal progress in spectrum auctioning and the market concentration *HHI**, the latter being predicted on the basis of the first step. In line with Tiedemann (2009), the model for retail prices encompasses as control variables the change and the squared change in the share of population living in predominantly rural areas, as a proxy for the cost of providing the service.

In order to increase the efficiency of the estimates, the estimation of the two steps has also been undertaken separately, including a proper correction for the standard errors ([35]), obtaining comparable results.

Table IV.2: **Determinants of (first difference) mobile prices - instrumental variable specification**

VARIABLES (first differences)	HHI (lagged)	(log) mobile price
	IV-FE (1st step)	IV-FE (2nd step)
Progress in spectrum auctioning (lagged)	-0.0939**	-0.3486*
	(-0.046)	(-0.2016)
HHI (lagged)		2.483*
		(1.3084)
Penetration rate of mobile subscriptions (lagged)	-0.1352***	
	(-0.048)	
Share of rural population (lagged)		133.9095
		(170.77)
Squared share of rural population (lagged)		-87.587
		(139.91)
Year dummies	yes	yes
Observations	105	105
Hansen J-test (p-value)		0.3185
Kleibergen-Paap LM test (p-value)		0.0197
Number of countries	27	27

(1) Robust standard errors in parentheses.
Constant term included. * significant at 10%; ** significant at 5%; *** significant at 1%.
Source: Own calculations

Overall, the interpretation of the findings is rather straightforward and consistent with the research hypothesis: on the one hand, marginal progress in spectrum auctioning is associated with a reduction in market concentration and, through the latter's positive and significant correlation with mobile

([35]) An IV approach has the advantage of introducing an appropriate correction for the correlation among the simultaneously estimated equations, while a pure two-sample-two-stage least squares (TS2SLS) allows to avoid constraining the sample to the least amount of observations (4 points in time for mobile prices). To the aim of the present work, the same model has also been estimated using, in lieu of an IV approach, a pure 2SLS with bootstrapped standard errors: previous examples in the literature using this method include Ciriaci D. (2013). The estimates in terms of overall impact, which are available upon request, are substantially the same as with the IV approach, with only marginal differences in terms of their repartition between the direct and indirect effect. Namely, the estimated coefficient on concentration to spectrum progress seems to be higher when based on less recent years (2007-2011), i.e. in the IV method: this could be in line with the intuition that the marginal effects of further spectrum progress are decreasing over time. Estimations have been run also with a quadratic term for HHI, which is not significant but has the expected negative sign.

retail prices (a change in market concentration by 1 p.p. is associated with a reduction in mobile prices by close to 2.5%), with a reduction in mobile retail prices by 2.3% (*indirect effect*); at the same time, spectrum progress is also associated with a further reduction in mobile retail prices by 3.4% (with a lag), not "explained" by changes in sectoral concentration: this *direct effect* could be the result of additional transmission channels, including technological innovation over newly assigned spectrum. Table IV.3 below summarises these results. For instance, if a Member State's overall spectrum compliance increased by 10 p.p., let us say due to a decision to assign the whole 2.0 GHz band to mobile providers, our estimations would foresee, on average, an overall decrease in sectoral prices, with a lag, by some 5.7%, of which: i) 2.3% through a negative impact on market concentration; ii) 3.4% due to other competitive pressures than reduced concentration, for instance channelled by technological innovation.

Graph IV.3 reports, respectively, the variation in the spectrum compliance indicator for each Member State between 2007 and 2013 ([36]), as well as the distance of its most recent value from an ideal policy target, consisting in having all analysed bands (the 800MHz, 900MHz, 1.8GHz, 2GHz, and 2.6 GHz) assigned to mobile operators, which corresponds to a unit compliance. The following column "translates" these "reform efforts" into policy shocks on mobile prices, based on the outlined estimations ([37]). Last but not least, the three final columns report the simulated economy-wide GDP impacts corresponding to these price shocks, based on the *QUEST III* model, respectively for the already observed, the further, and the overall reform effort.

([36]) We deliberately excluded from the "achieved effort" very recent auctions like the just closed Austrian, Finnish, and Latvian ones, as it is reasonable to assume that their effect is still to materialise, and thus to be included in the potential impact.

([37]) It is worth noting that the, in assessing the overall impact of spectrum reforms, the repartition of total effect between the direct and indirect one, which was the main difference observed between the results with the IV and 2SLS, is not used.

Table IV.3: **Effect of spectrum auctioning on mobile communications retail prices**

Dependent variable	Reform indicator/ explanatory variable	Simulated change in reform indicator/ explanatory variable	(Preliminary) effect on dependent variable	Comments
Changes in sectoral concentration (measured by a quasi-Herfindahl index for mobile communications)	Progress in spectrum compliance across 5 harmonised bands	Increase by 10 percentage points	Decrease by 1.4% - 1.6%	There is some evidence that this relationship is stronger in less recent years of the sample
Changes in sectoral retail price (measured as average revenue per minute of mobile voice communications)	Progress in spectrum compliance across 5 harmonised bands	Increase by 10 percentage points	Decrease by some 5.7% (direct impact and indirect one through changes in sectoral market concentration)	This impact takes place with a lag

Source: Own calculations

Graph IV.3: **Sectoral price decrease and GDP impacts (QUEST simulation) of spectrum-related structural reforms**

Country	Pursued spectrum progress 2007-2013	Gap to close in spectrum progress	Achieved sectoral price reduction (direct+indirect effect)	Further potential sectoral price reduction (direct + indirect effect)	Long-run GDP impact from already observed reform effort	Long-run GDP impact from further potential reform effort	Long-run overall GDP impact (QUEST simulation)
AT	0.12	0.43	6.7%	21.9%	0.08	0.11	0.18
BE	0.13	0.48	7.3%	24.1%	0.10	0.14	0.24
BG	0.15	0.54	8.5%	26.9%	0.12	0.28	0.41
CY	0.01	0.63	0.3%	30.8%	0.02	0.28	0.30
CZ	0.11	0.50	6.4%	25.3%	0.09	0.19	0.28
DE	0.59	0.00	29.2%	0.0%	0.12	0.01	0.13
DK	0.52	0.01	26.2%	0.6%	0.13	0.01	0.13
EE	0.37	0.28	19.1%	14.8%	0.15	0.10	0.25
EL	0.24	0.47	12.8%	23.8%	0.20	0.29	0.49
ES	0.44	0.01	22.7%	0.6%	0.32	0.01	0.33
FI	0.20	0.41	11.0%	21.2%	0.08	0.11	0.19
FR	0.44	0.02	22.8%	1.4%	0.18	0.01	0.20
HU	0.12	0.48	6.6%	24.5%	0.08	0.13	0.21
IE	0.60	0.06	29.4%	3.2%	0.15	0.02	0.17
IT	0.54	0.05	26.9%	2.9%	0.26	0.03	0.29
LT	0.58	0.03	28.6%	1.8%	0.16	0.02	0.19
LU	0.56	0.06	27.7%	3.4%	0.17	0.03	0.20
LV	0.20	0.42	11.1%	21.5%	0.14	0.21	0.35
MT	0.15	0.51	8.2%	25.7%	0.07	0.13	0.21
NL	0.54	0.00	27.0%	0.0%	0.15	0.01	0.16
PL	0.22	0.43	11.9%	22.3%	0.11	0.15	0.26
PT	0.55	0.12	27.4%	6.6%	0.29	0.06	0.35
RO	0.56	0.09	28.0%	5.3%	0.36	0.07	0.42
SE	0.62	0.02	30.2%	1.4%	0.17	0.01	0.19
SI	0.12	0.55	7.0%	27.2%	0.08	0.17	0.25
SK	0.13	0.55	7.1%	27.2%	0.09	0.19	0.28
UK	0.43	0.02	22.3%	1.0%	0.15	0.01	0.16
EU27	**0.43**	**0.13**	**22.3%**	**7.1%**	**0.17**	**0.04**	**0.21**

Source: Own calculations and QUEST III simulations

Overall, the EU-average achieved spectrum progress between before and after the crisis is slightly more than 40%, with marked differences among Member States: we estimate that this reform effort is associated with an average decrease in mobile prices by 21% to 22% ([38]): this should be compared with the actually observed price decrease over 2007-2011, amounting to some 38% EU-wide. On the other hand, if all Member States fully assigned their still available spectrum across the considered harmonised bands, thus reaching a cross-band compliance of 100% (as it is currently the case, e.g., for DE and NL), this would be associated with further potential price reduction by 7%. The economy-wide GDP impacts corresponding to these policy shocks (more details on their simulation are provided in the next Section) amount to 0.17% of GDP (over the baseline) in the long run for the already observed reform efforts and to 0.21% in the long run when also further reform effort is taken into account.

IV.1.2. QUEST III simulations

In Section IV.1.1., econometric analysis is carried out to test the hypothesised transmission channel for reforms enhancing radio spectrum allocation in the harmonised bands 800MHz, 900MHz, 1.8GHz, 2GHz, and 2.6 GHz. The estimated policy shocks are: i) a reduction in mobile retail prices (average revenue per minute of mobile communications) by some 22% EU-wide in relation to the already observed reform effort over 2006-2013, ranging from 0.3% in CY to 30% in SE; ii) further potential reduction in mobile prices by 7% on average, ranging between 0% in DE and NL and 30.8% in CY, in case of achieving full spectrum compliance. Table IV.4 below reports the *QUEST III* simulations for this competition channel, in particular the total impacts as from 2011, including both the already achieved licensing effort between 2006 and 2013, and the further potential, phased in over 5 years.

([38]) The impact should actually be considered fully observed by half-2014, due to the assumed lag structure in the model.

Table IV.4: **Spectrum policies, competition channel: GDP impacts by countries in % deviation from baseline**

Years	1	2	3	4	5	10	20	Long-run
AT	0.01	0.01	0.01	0.03	0.04	0.06	0.09	0.18
BE	0.02	0.02	0.02	0.05	0.07	0.09	0.13	0.24
BG	0.03	0.03	0.04	0.08	0.13	0.18	0.25	0.41
CY	0.01	0	0	0.05	0.09	0.12	0.17	0.3
CZ	0.01	0.02	0.02	0.07	0.09	0.11	0.16	0.28
DE	0.03	0.03	0.04	0.04	0.04	0.05	0.08	0.13
DK	0.03	0.03	0.04	0.04	0.04	0.05	0.07	0.13
EE	0.04	0.05	0.06	0.08	0.1	0.12	0.16	0.25
EL	0.04	0.04	0.05	0.09	0.13	0.17	0.25	0.49
ES	0.05	0.07	0.08	0.09	0.09	0.11	0.16	0.33
FI	0.02	0.02	0.02	0.04	0.05	0.07	0.1	0.19
FR	0.04	0.04	0.05	0.06	0.06	0.07	0.1	0.2
HU	0.01	0.01	0.02	0.05	0.07	0.08	0.12	0.21
IE	0.04	0.05	0.05	0.06	0.06	0.07	0.1	0.17
IT	0.05	0.06	0.07	0.08	0.08	0.1	0.15	0.29
LT	0.05	0.06	0.07	0.08	0.08	0.09	0.13	0.19
LU	0.05	0.06	0.07	0.08	0.08	0.09	0.12	0.2
LV	0.03	0.04	0.05	0.11	0.14	0.16	0.22	0.35
MT	0.01	0.02	0.02	0.05	0.08	0.1	0.13	0.21
NL	0.04	0.05	0.05	0.06	0.06	0.07	0.1	0.16
PL	0.02	0.03	0.03	0.07	0.09	0.1	0.14	0.26
PT	0.06	0.08	0.09	0.11	0.12	0.14	0.2	0.35
RO	0.09	0.1	0.12	0.14	0.15	0.18	0.25	0.42
SE	0.04	0.05	0.06	0.07	0.07	0.08	0.11	0.19
SI	0.02	0.02	0.02	0.05	0.08	0.1	0.15	0.25
SK	0.02	0.02	0.02	0.06	0.09	0.12	0.17	0.28
UK	0.04	0.05	0.05	0.06	0.06	0.07	0.1	0.16
EU27	**0.04**	**0.04**	**0.05**	**0.06**	**0.07**	**0.08**	**0.12**	**0.21**

(1) Total impact starting from 2011 (including already assigned spectrum and further potential phased over 5 year).
Source: QUEST III simulations

The features of the *QUEST III* model also allow to take into account a further transmission channel that could not be econometrically tested due to lack of data, namely capturing the economy-wide spill-over, first of all the productivity-enhancing impact over private operators, of the public capital deepening related to spectrum auctioning receipts, either actually received over 2010-2013 or foreseen in 2014. These revenues are reported in Table IV.5 below ([39]) and generally represent only a small fraction of each Member State's GDP. The GDP impact of capital deepening is related to the leverage effect assumed in the model of public capital deepening ([40]) on private investments: this includes a temporary productivity shock allowing for the cost reduction effects stemming from the policy scenarios considered in terms of broadband deployment (see Section IV.4), in that "soft" cost-reduction policies tend to apply also to wireless technologies ([41]).

Tables IV.6 and IV.7 below report the simulations for spectrum auctioning-related capital deepening. A parameter playing a crucial role in this exercise is the output elasticity of public capital (infrastructure): in fact, despite a large literature on infrastructure investment and economic growth,

([39]) Based on the latest information available in the Directorate General for Communications Networks, Content & Technology of the European Commission. The revenue forecasts, from the licencing in each Member State of the MHz to be assigned or reassigned per relevant frequency band, are based on the EU-wide simple average of the historical unit prices of radio spectrum frequencies (expressed in €/MHz/pop in each relevant band) registered in the auctions taking place between 2010 and 2013, excluding where possible the two extremes of the cross-country distribution.

([40]) The "wireless" component of the additional private investments foreseen by Analysys Mason (2013) has been quantified by the *Directorate General for Communications Networks, Content & Technology* of the European Commission.

([41]) The "wireless" component of the cost-reducing measures taken into account by Analysys Mason (2013) has been quantified by the *Directorate General for Communications Networks, Content & Technology* of the European Commission.

various econometric problems (common trends, missing variables, simultaneity bias, etc.) hinder the proper identification of this elasticity from macroeconomic time series. Therefore, two different scenarios, corresponding to two different calibrations of the model, are considered: in a "modest scenario", the output elasticity of public capital is set to 0.10, and the "wireless component" of both the leveraged private investments and the cost savings computed by the Commission Services is based on the "modest scenario" by Analysys Mason (2013); in a more optimistic "ambitious scenario", accounting for the possibility of higher than average productivity returns of ICT-related investments, the elasticity of public capital is set to 0.15 (i.e. 50% higher), and the "wireless component" of the leveraged private investments and of the cost savings refers to the "ambitious scenario" by Analysys Mason (2013). Overall, it is worth noting that: i) as opposed to genuine public infrastructure investments, revenues paid by the private sector for spectrum licenses do not enter directly into the GDP definition, i.e. only indirect productivity enhancing effects increase economic output; ii) as spectrum frequencies do not depreciate in technological terms, a depreciation rate is not applied to this measure. Overall, the simulations show gradually increasing productivity enhancing effects over time. After 5 years, the EU-wide GDP increase relative to the baseline is 0.11% in case of the modest intervention scenario and 0.16% under the optimistic scenario. The long-run GDP impacts are between 0.23% and 0.34%, which could be added up to the further potential GDP growth over the baseline, amounting to 0.04%, from the competition channel.

Table IV.5: **Revenues from spectrum assignments, expressed as a % of national GDP**

Country	Actual (2010-13)	Expected by 2014
AT	0.69%	0.00%
BE	0.04%	0.08%
BG	0.11%	0.00%
CY	0.00%	0.00%
CZ	0.00%	0.23%
DE	0.17%	0.00%
DK	0.10%	0.00%
EE	0.02%	0.75%
EL	0.20%	0.00%
ES	0.19%	0.00%
FI	0.06%	0.00%
FR	0.18%	0.00%
HU	0.00%	0.00%
IE	0.23%	0.00%
IT	0.25%	0.00%
LT	0.01%	0.00%
LU	0.19%	0.00%
LV	0.04%	0.00%
MT	0.05%	0.00%
NL	0.64%	0.00%
PL	0.06%	0.00%
PT	0.22%	0.00%
RO	0.51%	0.02%
SE	0.16%	0.03%
SI	0.00%	0.00%
SK	0.00%	0.00%
UK	0.14%	0.00%
EU27	**0.20%**	**0.01%**

Source: Commission Services and own calculations. 2010-13 revenues are expressed in 2011 GDP, and those expected by 2014 in 2013 (forecast) GDP

Table IV.6: **Spectrum policies, capital-deepening effect (modest): GDP impacts by countries in % deviation from baseline**

Years	1	2	3	4	5	10	20	Long-run
AT	0.32	0.55	0.65	0.69	0.73	0.83	0.9	1.13
BE	0.05	0.06	0.06	0.07	0.07	0.09	0.1	0.15
BG	0.07	0.11	0.15	0.19	0.23	0.43	0.45	0.51
CY	0.05	0.04	0.03	0.03	0.03	0.07	0.08	0.1
CZ	0.04	0.07	0.09	0.1	0.11	0.17	0.19	0.26
DE	0.09	0.11	0.11	0.12	0.12	0.15	0.17	0.22
DK	0.04	0.04	0.05	0.05	0.05	0.06	0.07	0.1
EE	0.05	0.04	0.03	0.02	0.02	0.03	0.03	0.06
EL	0.08	0.1	0.1	0.1	0.11	0.21	0.26	0.42
ES	0.08	0.1	0.1	0.11	0.11	0.18	0.21	0.33
FI	0.06	0.07	0.07	0.07	0.08	0.11	0.12	0.17
FR	0.07	0.07	0.06	0.06	0.06	0.09	0.1	0.14
HU	0.02	0.03	0.04	0.04	0.05	0.14	0.15	0.21
IE	0.07	0.08	0.08	0.08	0.08	0.12	0.13	0.17
IT	0.08	0.1	0.11	0.12	0.12	0.17	0.2	0.31
LT	0.05	0.04	0.03	0.02	0.02	0.03	0.03	0.05
LU	0.06	0.06	0.05	0.05	0.05	0.06	0.07	0.12
LV	0.02	0.05	0.06	0.07	0.07	0.1	0.11	0.14
MT	0.05	0.03	0.03	0.02	0.02	0.03	0.04	0.06
NL	0.11	0.13	0.14	0.14	0.14	0.16	0.17	0.21
PL	0.03	0.04	0.06	0.07	0.09	0.13	0.13	0.18
PT	0.1	0.13	0.15	0.16	0.16	0.2	0.22	0.3
RO	0.08	0.1	0.11	0.11	0.13	0.28	0.28	0.36
SE	0.05	0.05	0.06	0.06	0.06	0.08	0.09	0.12
SI	0.05	0.09	0.09	0.1	0.11	0.15	0.17	0.25
SK	0.05	0.1	0.12	0.14	0.15	0.24	0.27	0.35
UK	0.04	0.05	0.05	0.05	0.05	0.07	0.08	0.11
EU27	**0.08**	**0.09**	**0.1**	**0.11**	**0.11**	**0.15**	**0.16**	**0.23**

Source: QUEST III simulations

Table IV.7: **Spectrum policies, capital-deepening effect (ambitious): GDP impacts by countries in % deviation from baseline**

Years	1	2	3	4	5	10	20	Long-run
AT	0.46	0.81	0.96	1.03	1.08	1.22	1.33	1.67
BE	0.08	0.09	0.1	0.1	0.1	0.13	0.14	0.23
BG	0.09	0.14	0.2	0.26	0.32	0.59	0.63	0.75
CY	0.07	0.06	0.04	0.04	0.04	0.1	0.11	0.15
CZ	0.06	0.11	0.13	0.14	0.15	0.24	0.27	0.39
DE	0.12	0.16	0.17	0.17	0.18	0.22	0.24	0.32
DK	0.05	0.06	0.07	0.07	0.08	0.09	0.1	0.15
EE	0.07	0.06	0.04	0.03	0.03	0.04	0.05	0.09
EL	0.11	0.14	0.15	0.15	0.16	0.3	0.37	0.6
ES	0.11	0.14	0.15	0.16	0.17	0.26	0.3	0.48
FI	0.08	0.1	0.1	0.11	0.12	0.16	0.18	0.25
FR	0.09	0.1	0.09	0.09	0.09	0.13	0.14	0.21
HU	0.03	0.04	0.05	0.06	0.07	0.19	0.21	0.3
IE	0.1	0.12	0.12	0.12	0.12	0.18	0.19	0.25
IT	0.12	0.15	0.17	0.17	0.18	0.25	0.29	0.46
LT	0.07	0.06	0.04	0.03	0.03	0.04	0.04	0.07
LU	0.09	0.09	0.08	0.08	0.08	0.09	0.1	0.18
LV	0.03	0.07	0.09	0.09	0.1	0.14	0.16	0.21
MT	0.07	0.05	0.04	0.03	0.03	0.04	0.05	0.09
NL	0.15	0.19	0.21	0.21	0.21	0.23	0.25	0.32
PL	0.04	0.06	0.08	0.1	0.12	0.18	0.19	0.26
PT	0.14	0.2	0.22	0.23	0.24	0.29	0.32	0.44
RO	0.11	0.14	0.15	0.16	0.18	0.39	0.4	0.54
SE	0.06	0.07	0.08	0.09	0.09	0.11	0.13	0.17
SI	0.07	0.12	0.14	0.15	0.16	0.21	0.24	0.36
SK	0.08	0.14	0.18	0.2	0.22	0.34	0.39	0.52
UK	0.06	0.07	0.08	0.08	0.08	0.11	0.12	0.16
EU27	**0.11**	**0.14**	**0.15**	**0.15**	**0.16**	**0.21**	**0.24**	**0.34**

Source: QUEST III simulations

IV.2. THE ECONOMIC IMPACT OF PROFESSIONAL E-SKILLS POLICIES ([42])

The issues of digital literacy and e-skills, particularly in a professional setting, are high in the EU policy agenda. This is witnessed also by the fact that the DAE sets an ambitious agenda of reforms to be undertaken at the EU level and by the Member States to enhance digital literacy and inclusion, not least targeting the supply of ICT practitioners and e-business skills, necessary for innovation and growth. On the basis of this policy agenda, different Member States have already undertaken various reforms aimed to strengthen their population's and workers' e-skills (see Box IV.2), and further measures are in the pipeline in line with the DAE and initiatives like the recently launched *Grand Coalition on Digital Skills and Jobs*. However, these efforts mostly take the form of "soft" measures, providing indirect incentives to professional e-skills, such as public support to ICT training in SMEs, and conducive framework conditions like integration of ICT in education. This makes it hard to rely on available data to quantify each Member State's reform effort in this field: this would require having precise quantitative information on a "monitoring indicator" directly linked to this reform effort, such as, for instance, the exact amount of public funds destined to ICT training to firms' personnel in each sector. In the absence of such data, the operational assumption used to the aim of the present work is that the current level of e-skills in the workforce reflects the outcome and the effectiveness of (longer-term) e-skills-enhancing reforms undertaken by the Member States. This assumption is made reasonable by the fact that the presence of e-skills in the workforce can be regarded as a rather "structural" variable, exogenous to a certain extent in the short term.

([42]) Thanks are due to Canton Erik, who provided the underlying data on allocative efficiency for the econometric analysis based on European Commission (2013), and to Ulbrich Martin, for advice.

Box IV.2: EXAMPLES OF EUROPEAN AND NATIONAL REFORMS ENHANCING PROFESSIONAL ICT SKILLS

The *Digital Agenda for Europe* (DAE) sets an ambitious EU agenda of reforms to enhance digital literacy and ICT skills in a professional setting. Among the already undertaken ones are: 1) introducing digital literacy as a priority for the 2014-2020 European Social Fund; 2) developing tools to identify and recognise ICT practitioners' and users' competences, linked to the European Qualifications Framework and EUROPASS, as well as a European Framework for ICT Professionalism to increase the competences and the mobility of ICT practitioners across Europe; 3) making e-skills a priority of the 2010 *New skills for new jobs* Flagship, including the launch of a multi-stakeholder sectoral council for ICT skills and employment to address demand and supply aspects; 4) promoting higher participation of young women and women returners in the ICT workforce through support for web-based training resources, game based eLearning and social networking. On top of these measures, the Commission launched in March 2013 a *Grand Coalition on Digital Skills and Jobs*, a multi-stakeholder partnership expected to tackle the projected shortfall of up to 900000 ICT professionals in Europe by 2015, exacerbated by a decline in computing science graduates. This aims to increase the overall supply of e-skilled professionals and to better match supply and demand of digital skills through focussed actions, implemented in the short-term and with high local impact, such as: i) improved image and attractiveness of ICT careers; ii) training packages co-designed with the ICT industry; iii) more aligned degrees and curricula at vocational and university level education to respond to the students' and industry's needs; iv) enhanced recognition of qualifications across countries by stimulating the take-up of a EU certification scheme for digital skills of ICT professionals, based on the existing e-Competence Framework; v) reducing labour market mismatches by stimulating mobility; vi) fostering digital entrepreneurship by liaising with Start-up Europe, a single platform for tools and programmes supporting people wanting to set up and grow web start-ups in Europe. On their part, Member States are called upon to implement long-term e-skills and digital literacy policies and promote relevant incentives for SMEs and disadvantaged groups, but most of this effort is still ongoing. Concrete examples of actually undertaken e-skills reforms by some Member States, based on Empirica (2013), are:

Greece: Reforms undertaken in Greece have focussed more on digital literacy than on professional e-skills, with the exception of a few awareness-raising measures: e.g. the *Digital Literacy Activities* include ICT training of the workforce and ICT measures targeting the education system; the 2008 *Lifelong Learning Act* and the *Digital Convergence Project*, with a total budget of €2 billion, aim to develop effective and sustainable exploitation of ICT in the Greek economy, also through targets including: introduction on new technologies in secondary education, support to 20,000 businesses to improve their productivity, funding of 10 major hubs for digital services through public sector to businesses. Since June 2009, the *Interbalkan Institute* also offers a 50-hour training to public servants across six regions of Greece on issues related to e-government, basic computer skills, networks security, advanced computer skills, and specialist computer applications; training in e-learning platforms started in October 2012. Also, the *e-innovation* multi-stakeholder initiative achieved some results in boosting entrepreneurial activity in the digital domain (ICT start-ups).

Italy: Overall, some programmes supporting ICT and e-leadership skills have started in Italy, and computer science is now taught since primary school. In detail, the National executive Law for the implementation of the *Italian Digital Agenda Programme* was issued in October 2012, keeping up the e-Gov 2012 plan initiatives launched in 2009, and including short and mid-term actions in strategic axes like Digital Identity, Digital PA/Open Data, Digital school and University, Digital Health, Digital Justice, Digital Divide, e-payments. The launched operative plan aims to make up for Italy's delay in the EU in terms of e-investments, around 2% of the GDP (10% of total investments): some €2.5 billion from national and EU funds have been approved for the first year. Overall, specific initiatives on e-Leadership skills have not yet been planned by the government, although digital literacy in many business sectors, not least school itself, is still an evident need: indeed, e-skills supply and demand should match locally through initiatives addressing labour market requirements, given also the full autonomy of the Italian school. Still, the Italian government prioritised reforms aimed at awareness-raising (addressing critical topics such as cyber-security and eCommerce), digitalisation, and digital literacy of schools, teachers, and non-ICT micro enterprises.

(Continued on the next page)

Box (continued)

Namely, the so called *inter-professional funds* support vocational continuous training according to companies' requirements; a new law on apprenticeship regulates it at several proficiency and qualification levels, including the two-year "high apprenticeship" programme for young postgraduates. This is managed by universities together with enterprises and built according to the real needs perceived by the business locally. In this context, ICT training and e-Leadership initiatives have been developed at "high" apprenticeship level, which receives regional funds.

Portugal: E-skills are only slightly encompassed in Portugal's strategy for Information Society and promotion to broadband access, and only a few governmental initiatives are being actively implemented in this field, not least due to recent financial constraints, despite the fact that the *Digital Agenda for Portugal* sets among its targets the promotion of the use of new technologies, the increase in the number of firms resorting to eCommerce by 50% by 2016, and more ICT exports by 20% with respect to 2011. Exceptions are represented by: i) the *Strategic Program for Entrepreneurship and Innovation*, promoting ICT and digital entrepreneurship skills through tools like "entrepreneurship vouchers", helping new firms acquire consultancy services in business plan development and digital economy; ii) the *digital SME Programme*, promoted by the *Portuguese Association of Electronic Commerce and Interactive Advertising* and the *Institute for Supporting SMEs and Innovation*; iii) in the public sector, the implementation by the *Agency for Administrative Modernisation* of e-management initiatives and programmes to develop new skills to public servants and promote the development of ICT firms; for instance, the *Global strategic plan for rationalisation and cost reduction in ICT in the Public Administration* encompasses five e-skills-related objectives, including the improvement of ICT competences and necessary specialisation of human resources to enable the implementation of the strategic plan. Last but not least, the *Technological Plan for Education* launched in 2007 aim to ensure the necessary infrastructure and e-skills development initiatives to integrate ICT in teaching and learning processes: by 2011, almost one third of all teachers received training in ICT applied to teaching and had their ICT skills certified; *Team Resources and Educational Technologies* (ERTE) is a multidisciplinary team of the Portuguese Ministry of Education, managing all initiatives concerning ICT in schools, including ways of integrating effective use of ICT in curricula and teaching guidelines, at all levels of education and training.

Spain: Spanish policies have long focussed mainly on digital literacy, while initiatives to secure adequate supply of ICT practitioners have only recently gained ground, notably in the context of the Digital Agenda and at Autonomous Community level (e.g. Catalonia): e.g., training measures of the workforce, promotion measures, and measures targeted towards SMEs. For instance, in July 2010, the Spanish government approved the 2011-2015 Strategy for so-called *Plan Avanza*, a national plan to achieve adequate ICT use for economic growth, competitiveness, and productivity. One of its five action axes, to which 1.874 mn € are allocated, relate to e-skills and digital literacy. In particular, the "SME training" part includes projects, already in progress, to contribute to an economic model change in Spain through ICT use, helping SMEs implement e-business solutions like e-invoicing. The National Observatory for Telecommunications and Information Society (ONTSI) is in charge of monitoring the *Plan Avanza* and enabling dialogue between the ICT sector and different public administrations for the definition and evaluation of policies. On top of this, in September 2009 the Ministry of Education launched *Escuela 2.0*, a nationwide project to integrate ICT into school life, whereby nearly 650,000 students in the third cycle of primary education and the first cycle of ESO were provided with a laptop as a learning tool and 160,000 teachers participated in ICT-training by 2011. Last but not least, since February 2013 the *Digital Agenda for Spain* sets guidelines on e-targets to be achieved in line with the DAE, including promotion of e-literacy and ICT training for new professionals. While seven plans have already been issued in 2013 to achieve these targets (e.g. "ICT in SMEs and eCommerce"), their state of implementation varies among Autonomous Communities, although all have already worked on fostering e-administrations and the ICT industry, for instance through the *Digital Intergenerational Literacy Program of the Generalitat of Catalonia*. On the other hand, the Spanish ICT industry has become active in boosting e-skills in general and supply of ICT practitioners in particular: e.g., AMETIC (the Spanish association of electronics, ICT, telecommunications, and digital contents industries) engaged in an ICT training programme to unemployed to increase their employability, fully funded (until 2013, due to budget cuts) by the Agency of Employment SEPE.

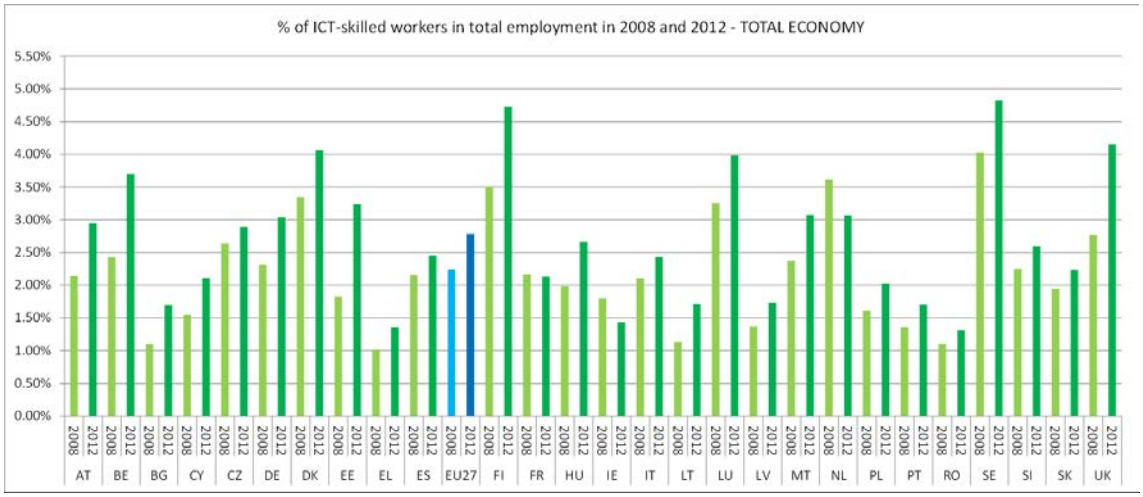
Graphs IV.4 to IV.6 below show the evolution between 2008 and 2012 of the percentage of workforce with specialized ICT-skills, respectively in the total economy, in manufacturing, and in business services. Data are based on the *EU Labour Force Survey* and the methodological approach described in Sabadash (2014) to fairly reflect professional ICT skills ([43]). The figures clearly show an increase in e-skilled workforce in most Member States, raising the EU average by some 27% (from 2.2% to 2.8%). This increase is less evident in the business services sector (by 17% EU-wide, from 8.9% to 10.4%) than in manufacturing (by some 25% EU-wide, from 1.5% to 1.9%), due to already higher shares of e-skilled workers before the crisis. On the basis of these observed specificities, future research could also investigate to what extent the impact of e-skills varies across sectors (e.g. for tradables and non-tradables).

Overall, the consistently observed growth in ICT-skilled employees across all sectors ([44]) and all MS seems to support the hypothesis of EU-wide reform efforts, in line with a key Digital Agenda pillar, to foster the development of adequate ICT skills in the labour force.

([43]) In such definition, ICT-skilled employment indicates employees in occupations where they use specialized ICT skills to various degrees across all industries (as opposed to employment in the ICT sectors only), based on the thematic view for ICT occupations proposed by ILO (2012). Although ICT specialists are taken into account, as opposed to the wider category of ICT users, the adopted definition is broader than previous works (e.g. OECD 2012), as it includes a wider range of ICT occupations from the International Standard Classification of Occupations (ISCO) and a reference to actual skills taxonomies when non-ICT professions are taken into account, as in Sabadash (2014).

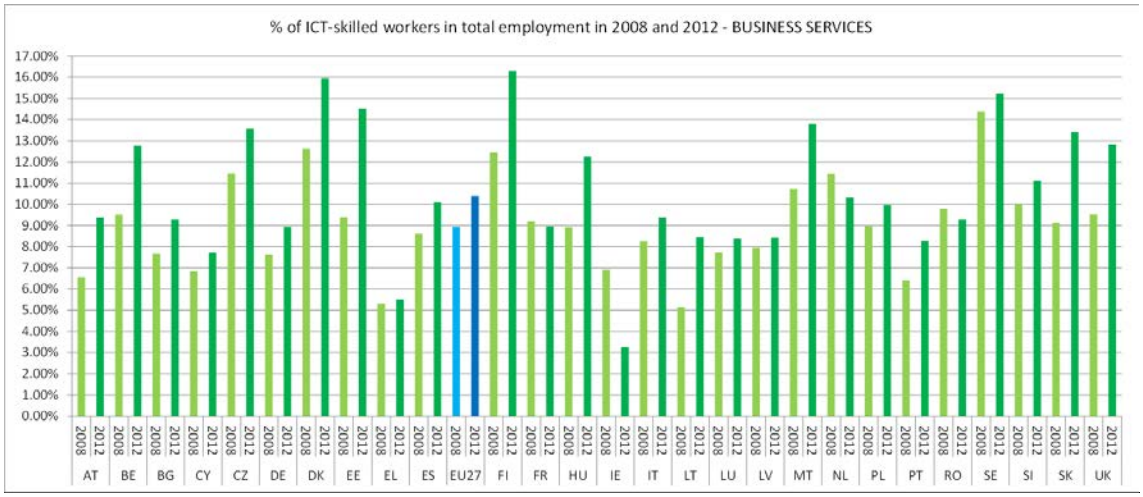
([44]) The available Eurostat dataset covers 7 broad sectors: "Agriculture, Forestry, and Fishing", "Mining and Electricity, Water, Waste", "Manufacturing", "Construction", "Trade, Transport, Tourism", "Business services", and all "Other services".

Graph IV.4: **2008-2012 evolution of the share of ICT-skilled workforce in the total economy**



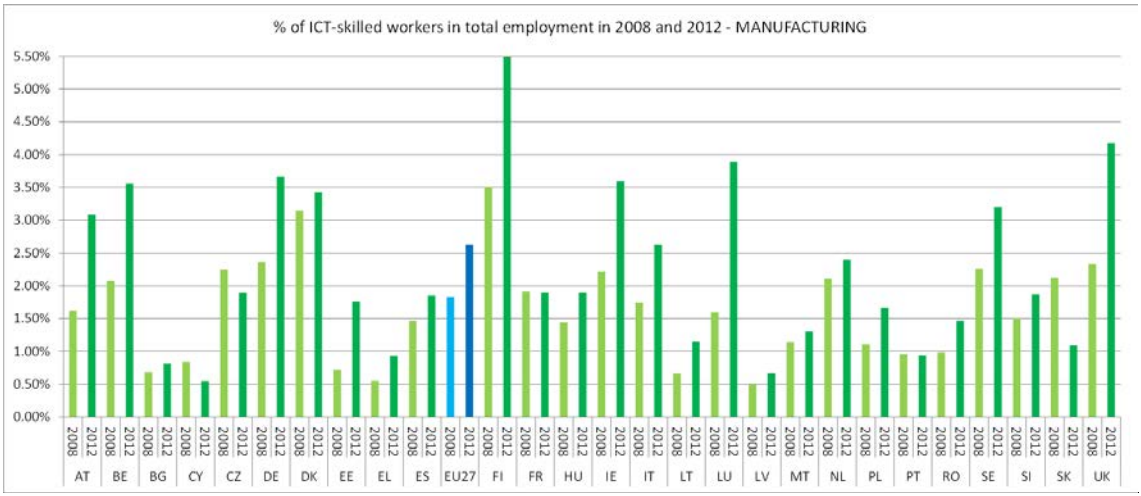
Source: Eurostat LFS

Graph IV.5: **2008-2012 evolution of the share of ICT-skilled workforce in business services**



Source: Eurostat LFS

Graph IV.6: **2008-2012 evolution of the share of ICT-skilled workforce in manufacturing**



Source: Eurostat LFS

IV.2.1. Identified transmission channels and partial-equilibrium results

This Section aims to contribute to the assessment of the economic impact of structural reforms enhancing professional e-skills, by empirically investigating the impact of changes in the sectoral shares of ICT-skilled workforce on the efficiency of intra-sectoral resources reallocation. As outlined also in Chapter III, the underlying economic rationale is supported by a long-standing literature on the role of human capital and skills in improving the allocative efficiency, and thereby the productivity, of the economic system. In fact, echoing the "acquired allocative ability" mentioned in Huffman (1977), one can assume that, in a rapidly developing high-tech environment, ICT-related skills may play a role in improving the economic agents' ability to efficiently respond to changes in competitive and economic conditions that increasingly require collecting, retrieving, analysing, and communicating information in order to perceive the change and quickly react to it. The interest of this analysis, original to the best of our knowledge, also lies in the fact the actual use of ICT, first of all among those who contribute to the productive processes, is shown to matter at least as much as its mere availability to unleash an economy-wide impact on productivity: indeed, adequate ICT-skills are a pre-condition to allow sufficient take-up of ICT among the labour force and in the overall population. More broadly, this analysis also sheds light on the functioning of business dynamics as a transmission channel of ICT-fuelled shocks, showing the importance of e-skills to improve intra-sectoral allocative efficiency.

The hereby presented econometric analysis is based on a panel of the mentioned Eurostat data on sectoral shares of e-skilled workforce and of allocative efficiency (AE) data, measured by an indicator empirically implemented in European Commission (2013) as a sector-level variant of the decomposition of labour productivity proposed by Olley and Pakes (1996). This measures the extent to which productive factors are allocated towards their most efficient use, by comparing labour productivity and market shares of firms in different size classes ([45]): estimates of the AE-index can thus be straightforwardly interpreted as increases in sectoral productivity, related to the actual allocation of employment across firm-size classes, relative to a baseline scenario in which employment is allocated randomly across the different firm size categories. Overall, the panel covers four broad sectors ("Manufacturing", "Construction", "Trade, Tourism, and Transport", and "Business Services") ([46]) for the time period

([45]) This is done in European Commission (2013) by taking average values within each size class and approximating market shares with the employment of the firms in a size class as a share of total employment within the sector.

([46]) An important assumption underlying the analysis is that the structure of e-skills does not significantly change across the sub-components of the broad sectoral aggregations under scrutiny (e.g. G, H, and I, within the sector G-I). This

2000-2010, and for almost all EU countries (although data on Greece and Malta are limited). The estimated model has the following form:

$$AE_{ijt} = a_1 + a_2 Skills_{ijt} + a_4 X_{ijt} + a_5 D_t + a_5 D_j + \varepsilon_{ijt} + \omega_i \quad (4)$$

where *AE* and *Skills* are, respectively, the allocative efficiency index and the employment share of ICT-skilled workers in country *i*, sector *j* and year *t*; *X* is a vector of control variables, including, e.g., firms' entry rates and size at birth in line with European Commission (2013) ([47]); *D* is a vector of year and sector dummies, controlling, respectively, for time-specific shocks and for sectoral specificities (for instance, a different technological intensity across sectors). Table IV.8 below reports the obtained findings for alternative specifications, among which a Hausman test indicates a preference for the fixed-effects model. The findings indicate that the percentage share of ICT-skilled workers in total employment has a statistically significant positive effect on AE: namely, an increase by 1 p.p. in such share in sector *i* is associated with an increase in AE of sector *i* by between 1.2 and 1.3 p.p. These findings confirm the significant positive spill-overs from adequate presence of ICT skills in the labour force, and hint at their role in ensuring also proper functioning of major transmission channels of ICT-related policies to productivity as identified in the literature, e.g. the process of reallocation of resources from less to more productive firms.

Table IV.8: **Determinants of allocative efficiency - effect of sectoral shares of e-skilled workers**

VARIABLES	AE-index		
	OLS	FE	RE
ICT-skilled employees %	1.983***	1.197**	1.285***
	(-0.278)	(-0.544)	(-0.496)
Entry rate	0.002***	0.003**	0.003**
	(-0.001)	(-0.001)	(-0.001)
Employment at birth	0.013**	0.034**	0.030**
	(-0.005)	(-0.016)	(-0.015)
Employment at birth (squared)	0.000	-0.002*	-0.001*
	(0.000)	(-0.001)	(-0.001)
Sector dummies	yes	yes	yes
Year dummies	yes	yes	yes
Observations	1017	1003	1003
R-squared	0.548	0.641	0.555
Number of countries	27	27	27

(1) Robust standard errors in parentheses.
Constant term included. * significant at 10%; ** significant at 5%; *** significant at 1%
Source: Own calculations

The obtained estimates are hereby used to quantify "a policy shock" on AE and thereby on labour productivity ([48]), stemming from each Member State's progress in terms of sectoral shares of ICT-skilled workforce (assumed to be a *prima facie* approximation of their reform effort ([49])), both actually observed in the past and projected in line with the DAE targets. As for the past effort, Table IV.9 summarises the quantified impacts, respectively on AE and labour productivity, of the change, over 2008-2012, in the structure of e-skilled employment in four Member States (sectoral impacts for the other Member States are available upon request) and in the EU27. These are

allows linking the two indicators, being the productivity decomposition available at the Nace Rev. 2 letter level.

([47]) European Commission (2013)

([48]) The quantification of the relationship between labour productivity and allocative efficiency is based on the results from a regression analysis of (the logarithm of) labour productivity at sectoral level on the allocative efficiency indicator, controlling for country and sector dummies as presented in European Commission (2013). The reported semi-elasticity is 0.73%, implying that an increase in AE by 1 p.p. is associated with an increase in labour productivity by 0.73%.

([49]) To improve on this operational assumption, some preliminary analysis has been undertaken, finding positive correlation between the lagged firms' offer of general and specialised ICT training to their staff and the share of ICT-skilled workers in the economy (based on a RE panel regression on sectoral data for 2006 and 2010). However, scarce availability of data prevented a full-fledged analysis, for instance in that a longer lag should likely be assumed. Not least, ICT training could in turn be considered the broader outcome of more specific reforms efforts like increasing public funds to support this kind of training. Further research should thus try to identify properly exogenous reform variables and perform a two-step approach to test the impact of a better quantified reform effort on AE/labour productivity, through the transmission channel of enhanced e-skills in the workforce.

Table IV.9: **Estimated impacts on AE and labour productivity of observed e-skills progress**

Country	Sector	Increase (in p.p.) in the share of ICT-skilled workforce over 2008-2012	Estimated impact (in p.p.) on AE	Estimated impact (in p.p.) on labour productivity
Greece	Manufacturing	0.38	0.45	0.34
	Business Services	0.2	0.24	0.18
	Total economy	0.35	0.41	0.31
Italy	Manufacturing	0.89	1.06	0.8
	Business Services	1.13	1.35	1.01
	Total economy	0.32	0.38	0.29
Portugal	Manufacturing	-0.02	-0.03	-0.02
	Business Services	1.88	2.24	1.68
	Total economy	0.34	0.41	0.3
Spain	Manufacturing	0.39	0.46	0.35
	Business Services	1.51	1.81	1.36
	Total economy	0.3	0.36	0.27
EU27	Manufacturing	0.8	0.95	0.71
	Business Services	1.46	1.75	1.31
	Total economy	0.54	0.65	0.49
	2020 Target	0.404	0.483	0.36

Source: Own calculations

based on the estimated semi-elasticities and should be regarded as an average effect across all sectors included in the analysis; besides, in extending this impact to the overall economy, the underlying assumption is that other sectors behave on average as those analysed. Overall, in spite of marked differences among countries, the observed 0.54 p.p. increase in the share of ICT-skilled workforce in the EU over 2008-2012 can be expected to be associated with an increase in AE by 0.7 p.p. and in labour productivity by 0.5 p.p.

The presented regression analysis allows also to compute the economic impact of further reform effort to enhance professional e-skills in the EU, in line with the DAE. In fact, over and above broader measures to enhance the overall digital literacy of the EU population, initiatives like the recently launched *Grand Coalition on Digital Skills and Jobs* explicitly aim to bridge a projected gap ([50]) of up to 900,000 ICT professionals in Europe by 2015. Therefore, the potential outcome of further e-skills-related structural reform effort can be operationally proxied with the achievement of this policy target of bridging the projected gap of ICT-professionals EU-wide by 2020; more precisely, this is hereby assumed to happen in each Member State in an inversely proportional manner with respect to the current national shares of ICT-skilled employment, since the impact of skills-enhancing measures can be reasonably expected larger in less "saturated" Member States ([51]). On the basis of these hypotheses, Table IV.10 below reports, for each Member State, the projected growth in ICT-professional by 2020 and the corresponding policy shock on AE and labour productivity from the estimated coefficients. Overall, the results indicate that bridging the projected gap of 900,000 ICT-professionals EU-

([50]) The 25/10/2013 European Council conclusions (www.consilium.europa.eu/uedocs/cms_data/docs/pressdata/en/ec/139197.pdf) indicated that "*users must have the necessary digital skills. Many European citizens and enterprises currently do not use IT sufficiently. This results in a growing difficulty in filling digital jobs. In 2011, the European Union was faced with 300,000 unfilled vacancies in the ICT sector; if this trend is not checked, there could be as many as 900,000 unfilled vacancies by 2015. This skills mismatch is detrimental to our economic and social policy objectives.*"

([51]) The used formula is $x_i = \frac{e_b}{e_i}\frac{x_b}{y_b}y_i$ where xi indicates the growth in ICT professionals in country i (b being the best performer EU-wide), y the total number of specialists, and e the relative employment share.

Table IV.10: **Estimated impacts on AE and labour productivity of further e-skills progress**

Country	ICT-employment share in 2012 (in %)	Projected additional ICT-skilled workers (p.p.)	Estimated impact (in p.p.) on AE	Estimated impact (in p.p.) on labour productivity
AT	2.9	0.403	0.482	0.361
BE	3.7	0.399	0.478	0.359
BG	1.7	0.408	0.488	0.366
CY	2.1	0.406	0.486	0.365
CZ	2.9	0.403	0.482	0.362
DE	3	0.402	0.481	0.361
DK	4.1	0.398	0.476	0.357
EE	3.2	0.401	0.48	0.36
EL	1.4	0.409	0.49	0.367
ES	2.5	0.405	0.484	0.363
FI	4.7	0.395	0.473	0.355
FR	2.1	0.406	0.486	0.364
HU	2.7	0.404	0.483	0.362
IE	1.4	0.409	0.489	0.367
IT	2.4	0.405	0.484	0.363
LT	1.7	0.408	0.488	0.366
LU	4	0.398	0.477	0.358
LV	1.7	0.408	0.488	0.366
MT	3.1	0.402	0.481	0.361
NL	3.1	0.402	0.481	0.361
PL	2	0.406	0.486	0.365
PT	1.7	0.408	0.488	0.366
RO	1.3	0.409	0.49	0.368
SE	4.8	0.395	0.473	0.354
SI	2.6	0.404	0.484	0.363
SK	2.2	0.406	0.485	0.364
UK	4.2	0.398	0.476	0.357
EU27	2.8	0.404	0.483	0.362

Source: Own calculations

wide as of 2020 is associated with 0.5 p.p. more allocative efficiency and close to 0.4 p.p. higher labour productivity.

IV.2.2. QUEST III simulations

In the previous Section, a reallocation channel for reforms increasing the Member States' sectoral shares of ICT-skilled workforce has been tested; namely, the estimated policy shocks are: i) an increase in labour productivity by some 0.5 p.p. EU-wide due to the observed change in ICT-skilled workforce over 2008-2012; ii) a further increase in labour productivity by close to 0.4 p.p. due to the achievement of the policy target of 900,000 more ICT-skilled workers.

Tables IV.11 and IV.12 below reports the *QUEST III* simulations corresponding to these policy shocks, imputed as labour productivity shocks phased in over 10 years, to account for implementation delays, and assuming that no costs are associated to the increase in the employment share of ICT-skilled workforce, e.g. due additional education expenditures. The simulation results ([52]) indicate that already achieved e-skills progress corresponds to a steady-state GDP impact of 0.59%, and that the impact of further reform effort could be 0.44% of GDP in the long-run.

([52]) For FR, IE, and NL the past policy shock was negative, no simulations have been performed and a zero impact is thus reported.

Table IV.11: **E-skills policies (observed over 2008-2012) - GDP impacts by countries in % deviation from the baseline**

Years	1	2	3	4	5	10	20	Long-run
AT	0.16	0.26	0.34	0.42	0.5	0.56	0.66	0.94
BE	0.22	0.41	0.54	0.67	0.8	0.86	0.96	1.43
BG	0.12	0.18	0.22	0.28	0.32	0.37	0.41	0.57
CY	0.11	0.18	0.24	0.29	0.35	0.39	0.43	0.57
CZ	0.04	0.08	0.1	0.12	0.15	0.17	0.19	0.27
DE	0.13	0.22	0.29	0.38	0.43	0.49	0.56	0.74
DK	0.14	0.23	0.31	0.38	0.45	0.5	0.56	0.75
EE	0.28	0.46	0.6	0.74	0.88	0.98	1.09	1.44
EL	0.07	0.11	0.14	0.17	0.19	0.21	0.25	0.4
ES	0.06	0.1	0.12	0.15	0.18	0.2	0.23	0.37
FI	0.25	0.4	0.52	0.65	0.77	0.86	0.96	1.42
FR	0	0	0	0	0	0	0	0
HU	0.12	0.2	0.27	0.34	0.39	0.44	0.5	0.69
IE	0	0	0	0	0	0	0	0
IT	0.06	0.09	0.12	0.15	0.17	0.2	0.24	0.38
LT	0.11	0.17	0.24	0.3	0.34	0.37	0.41	0.53
LU	0.15	0.24	0.31	0.41	0.46	0.5	0.55	0.76
LV	0.07	0.12	0.15	0.19	0.21	0.25	0.28	0.37
MT	0.12	0.19	0.26	0.33	0.4	0.44	0.49	0.63
NL	0	0	0	0	0	0	0	0
PL	0.08	0.12	0.17	0.21	0.24	0.26	0.3	0.44
PT	0.07	0.11	0.14	0.17	0.21	0.23	0.27	0.38
RO	0.04	0.07	0.09	0.1	0.12	0.14	0.16	0.23
SE	0.16	0.26	0.36	0.44	0.52	0.58	0.66	0.87
SI	0.07	0.11	0.15	0.19	0.22	0.25	0.27	0.37
SK	0.05	0.09	0.11	0.14	0.16	0.19	0.21	0.3
UK	0.28	0.45	0.62	0.76	0.9	1.01	1.11	1.42
EU27	**0.11**	**0.16**	**0.23**	**0.28**	**0.32**	**0.36**	**0.42**	**0.59**

Source: QUEST III simulations

Table IV.12: **E-skills policies (projected) - GDP impacts by countries in % deviation from the baseline**

Years	1	2	3	4	5	10	20	Long-run
AT	0.08	0.13	0.17	0.21	0.25	0.28	0.33	0.47
BE	0.07	0.13	0.17	0.21	0.25	0.27	0.3	0.45
BG	0.08	0.12	0.15	0.19	0.22	0.25	0.28	0.39
CY	0.08	0.13	0.17	0.21	0.25	0.28	0.31	0.41
CZ	0.07	0.12	0.16	0.19	0.23	0.26	0.3	0.43
DE	0.07	0.12	0.16	0.21	0.24	0.27	0.31	0.41
DK	0.08	0.13	0.17	0.21	0.25	0.28	0.31	0.42
EE	0.08	0.13	0.17	0.21	0.25	0.28	0.31	0.41
EL	0.08	0.13	0.16	0.2	0.23	0.25	0.29	0.47
ES	0.08	0.13	0.17	0.2	0.24	0.27	0.31	0.5
FI	0.08	0.13	0.17	0.21	0.25	0.28	0.31	0.46
FR	0.08	0.13	0.17	0.21	0.24	0.28	0.31	0.46
HU	0.07	0.12	0.16	0.2	0.23	0.26	0.3	0.41
IE	0.07	0.11	0.15	0.18	0.21	0.23	0.26	0.36
IT	0.07	0.12	0.15	0.19	0.22	0.25	0.3	0.48
LT	0.08	0.12	0.17	0.21	0.24	0.26	0.29	0.37
LU	0.08	0.13	0.17	0.22	0.25	0.27	0.3	0.41
LV	0.08	0.13	0.17	0.21	0.24	0.28	0.31	0.41
MT	0.07	0.11	0.15	0.19	0.23	0.25	0.28	0.36
NL	0.08	0.13	0.17	0.22	0.25	0.28	0.31	0.41
PL	0.08	0.12	0.16	0.2	0.23	0.25	0.29	0.43
PT	0.08	0.13	0.17	0.21	0.25	0.28	0.32	0.46
RO	0.08	0.13	0.17	0.2	0.23	0.27	0.31	0.46
SE	0.08	0.13	0.18	0.22	0.26	0.29	0.33	0.43
SI	0.08	0.13	0.18	0.22	0.26	0.29	0.32	0.43
SK	0.07	0.12	0.16	0.2	0.23	0.26	0.3	0.42
UK	0.08	0.13	0.18	0.22	0.26	0.29	0.32	0.41
EU27	**0.08**	**0.12**	**0.17**	**0.21**	**0.24**	**0.27**	**0.31**	**0.44**

Source: QUEST III simulations

Box IV.3: EXAMPLES OF EUROPEAN AND NATIONAL REFORMS FOSTERING ECOMMERCE

The DAE measures, mostly already undertaken, to foster a vibrant Digital Single Market (DSM) for eCommerce include: 1) ensuring the completion of the Single Euro Payment Area (SEPA), eventually facilitating the emergence of an interoperable e-Invoicing framework; 2) providing cross-border recognition and interoperability of secure e-Authentication systems through a revised e-Signature Directive and swift MS' implementation/transposition of key Directives supporting the DSM (e.g. Services Directive, Unfair Commercial Practices Directive, VAT Directive, and Telecoms Framework); 3) enhancing individuals' confidence and strengthening their rights; 4) complement the Consumer Rights Directive to overcome the fragmentation of contract law as regards the online environment; 5) proposing a EU-wide Online Dispute Resolution system for eCommerce transactions; 6) exploring ides on collective redress; 7) issuing a Code of EU Online Rights by 2012 that summarises existing digital user rights in the EU in a clear and accessible way.

Examples of actually undertaken eCommerce reforms by the Member States, in line with the DAE priorities are:

Italy: Over the recent years, the Italian government made some progress in fostering eCommerce, mainly through enhanced framework conditions. These include: i) the extension of cloud computing in the PA and the progressive extension of the possibility of e-payment to the PA through the so-called *Node of Payments*, the infrastructure connecting all Pas to ensure high levels of safety and reliability in transactions; ii) fully operational e-Invoicing as of June 2014 for the central PA, and as of June 2015 for all local ones; iii) imminent specification of minimum amounts, methods, and terms to make operational the new obligation for sellers of products and services to accept payments through debit cards, and imminent reduction of bank fees for payments made by debit and credit cards; iv) the so-called *web-tax*, whereby since July 2014 those who buy online advertising services and sponsored links, also through media centres and third-party operators, must purchase them from holders of a VAT number issued by the Italian tax authorities; also, online advertising spaces and sponsored links, which appear in search engines on the Italian territory during the visit of a website or the use of an online service, must be purchased exclusively through service providers like publishers, advertising agencies, search engines, or other advertisers, holding a VAT number issued by the Italian tax authorities. However, one could argue that the web-tax might have a negative impact on the provision of online advertising business, as it may *de facto* prevent it cross-border, if seekers of online advertising services can be fined for contracting with non-Italian VAT number holders. Last but not least, while in Italy the EU eCommerce legislation is almost properly implemented, there is quite high legal uncertainty around provision like the "online intermediaries"' liability, which could explain why some DAE initiatives are often lagging behind.

Spain: In Spain, recent political initiatives aimed to boost online services and eCommerce include: i) stronger rules on consumers' protection applying also to eCommerce, currently under vote in the Congress of Deputies; ii) better guidance on the use of "cookies", approved in 2013 in agreement with the industry and the *Agencia Española de Protección de Datos*; iii) impulse to e-Invoicing: this will be compulsory as of January 2015 in all public contracts, and it is encouraged for private contracts among firms and their clients especially for provision of public services of general economic interest; iv) stronger cyber-security rules, included both in the reform, under legislative process, of IPR, and in the modified *Ley de regulación del juego y de la Ley de servicios de la sociedad de la información y de comercio electrónico*; v) programmes by the State Administration to foster eCommerce targeting SMEs, self-employees and entrepreneurs; vi) stronger and safer e-Signature and e-Authentication through the National Document of e-Identity (DNIe).

IV.3. THE ECONOMIC IMPACT OF ECOMMERCE POLICIES ([53])

The *Digital Agenda for Europe* (DAE) includes a series of key policy measures aimed to foster a vibrant Digital Single Market, above all by making online and cross-border transactions easier and building digital confidence: namely, one of the DAE key performance targets foresees that at least 33% of European SMEs should conduct on-line purchases/sales by 2015. In line with these policy targets, some reform efforts have been undertaken by the Member States to spur online cross-border transactions and build digital confidence (see Box IV.3). Still, the latest Digital Agenda Scoreboard suggests that in 2010 only 15% of enterprises made electronic sales in the EU27, and that the turnover share from trading of goods or services over computer networks was stable at 14% over 2009 and 2010: all this indicates that eCommerce is still a small part of the EU enterprises' business models, complementing their traditional commercial activities of selling and buying, and that there still exists a considerable potential to exploit for further ambition.

IV.3.1. Identified transmission channels and partial-equilibrium results

This Section draws upon previous literature on the impact of eCommerce take up, briefly outlined in Chapter III, in order to test two transmission channels, through which reform efforts fostering eCommerce are assumed to affect the overall economy: i) an *efficiency channel*, capturing the impact on total factor productivity (TFP) of increased e-sales among firms, in turn fostering their productivity: the main *caveat* lies here in the difficulty to quantify the Member States' actual reform effort other than on the basis of observable outcomes; ii) a *competition channel*, mostly working through downward pressure exerted over average retail prices due to increased shares of online sales, characterised in turn by lower and less dispersed prices ([54]).

As for the first transmission channel, there are several theoretical reasons to assume that firms' recourse to e-trade could lead to improvements in their productivity (growth), including the effect of organisational learning, flexibility, and adoption of innovative practices. As mentioned in Chapter III, Eurostat (2008) and Hagsten (2013) investigate the impact on productivity of ICT use over and above the physical availability of ICT infrastructure, and the most conservative among their reported findings indicate that an increase in the share of firms resorting to e-sales by 10 p.p. is associated to an average increase in TFP by 0.54%. On this basis, we hereby obtain an approximated estimation of the productivity impact of the actual increase in e-sales intensity (measured as the percentage of firms resorting to electronic means for their sales) observed over 2010-2012, reported in Table IV.13 below. Clearly, it is important to read these results with full awareness of the *caveats* ([55]). On the other hand, the econometric analysis allows also to obtain a lower-bound

([53]) Thanks are due to Duch-Brown Néstor (JRC/IPTS) for sharing his estimated eCommerce demand, Papa Gianluca, for his advice and support on projection of eCommerce shares, and Giannakouris Konstantinos for expert data support. Thanks are also due to Stengg Werner, Sparas Denis, and Imarisio Carlo for information on eCommerce reforms in Italy and Spain.

([54]) Further research is in the pipeline in JRC/IPTS in order to clarify whether this competition effect consists only in a price effect, related to the expansion of existing trade thanks to online sails, or also in a quantity effect, due to the displacement of offline trade in favour of online ones.

([55]) A first caveat relates to the fact that the elasticity used in the computations is the most conservative one estimated in Eurostat (2008) for the specific case of NL and UK, the only Member States where data on both ICT and non-ICT capital were available: indeed, the limitation of the analysis to few Member States suggests a conservative approach. Namely, the used estimate refers to the impact of e-sales intensity on TFP for the case of Dutch "differentiated services": this finds support in the fact that, EU-wide and for the latest available year, e-sales intensity in the manufacturing sector was in line with the total economy (16%), while it was higher in distribution services (23%). This suggests a lower-than-average intensity in differentiated services, where most improvement might thus concentrate. A second caveat is related to the marked evidence of cross-country heterogeneity mentioned in Eurostat (2008): however, it is worth noting that the statistical relation is argued to vary in relation to the presence of a certain "critical mass" of ICT use at national level. Therefore, since the used estimates refer to two countries (NL and UK) already characterised in 2008 by a higher-than-average ICT-maturity at EU level, one could argue that the relevant statistical relationship might converge towards this value also for other Member States, as they become more "ICT-mature". In any case, the reported results should be considered as a preliminary attempt, with further checks and refinements ongoing, also on the basis of more recent analyses in the trail of Eurostat (2012) and Eurostat (2014).

Table IV.13: **TFP impact of e-sales intensity shock**

Country	% of firms selling online (2010)	% of firms selling online (2012)	Estimated impact on TFP (from observed effort)	Estimated impact on TFP (from reaching DAE target)
AT	17.75%	15.58%	-0.12%	0.94%
BE	29.16%	23.56%	-0.30%	0.51%
BG	3.79%	6.84%	0.16%	1.41%
CY	7.42%	8.10%	0.04%	1.34%
CZ	20.56%	25.61%	0.27%	0.40%
DE	23.92%	24.46%	0.03%	0.46%
DK	29.26%	29.06%	-0.01%	0.21%
EE	10.76%	12.63%	0.10%	1.10%
EL	9.22%	9.24%	0.00%	1.28%
ES	12.96%	14.20%	0.07%	1.02%
FI	18.92%	20.75%	0.10%	0.66%
FR	14.20%	14.15%	0.00%	1.02%
HU	8.97%	11.61%	0.14%	1.16%
IE	20.95%	23.35%	0.13%	0.52%
IT	5.03%	6.24%	0.07%	1.45%
LT	21.94%	17.22%	-0.25%	0.85%
LU	14.85%	16.33%	0.08%	0.90%
LV	6.96%	9.06%	0.11%	1.29%
MT	17.27%	17.70%	0.02%	0.83%
NL	23.57%	20.01%	-0.19%	0.70%
PL	8.71%	10.87%	0.12%	1.20%
PT	19.42%	14.94%	-0.24%	0.98%
RO	6.49%	5.39%	-0.06%	1.49%
SE	25.14%	27.07%	0.10%	0.32%
SI	12.43%	16.34%	0.21%	0.90%
SK	7.88%	14.00%	0.33%	1.03%
UK	17.10%	20.68%	0.19%	0.67%
EU27	**14.85%**	**16.10%**	**0.07%**	**0.91%**

Source: Eurostat and Eurostat (2008). The E-AESELL indicator for e-sales intensity is defined as the percentage of enterprises (of at least 10 employees, excluding the financial sector) having received orders in the past year via computer-mediated networks.

approximation of the productivity impact of further measures fostering the take-up of eCommerce among firms, in line with the DAE. The further potential policy shock can thus be quantified, for each Member State, on the basis of bridging the gap between the current e-sales intensity and the DAE key performance target whereby at least 33% of firms should be selling online by 2015 ([56]). Table IV.13 reports the estimated TFP impacts of this projected increase in the take-up of eCommerce among firms in each Member State. Overall, the estimated policy shocks for the EU amount to 0.07% of TFP for the observed reform effort and to further 0.9% for the further one.

As for the second transmission channel, the analysis in Duch-Brown and Martens (2014) outlined in Chapter III, is hereby adapted to estimate the policy shock related to observed reform efforts in the field of eCommerce, channelled through a competition (price) effect. Namely, a pooled log-linear demand equation is estimated across all product categories in their 2009 database to obtain the average difference in price elasticities between the online and the offline channel: this is fairly representative, as the covered products represent 26% of total consumers' online purchases in the EU, based on Civit Consulting data. The model takes the following form:

$$lnP_{ijc} = b_1 + b_2 Online + b_3 X_{ij} + b_4 D_c + b_5 D_i + b_6 D_j + \varepsilon_{ijc} \quad (4)$$

$$lnQ_{ijc} = a_1 + a_2 lnP_{ijc} + a_3 [lnP_{ijc} * Online] + a_4 Y_c + a_5 D_c + a_5 D_i + a_6 D_j + \varepsilon_{ijc} \quad (5)$$

([56]) While the DAE target refers specifically to SMEs, the fact that the e-trade intensity is usually positively correlated with business size (meaning that bigger firms are more likely to integrate ICT, including e-sales, in their business processes), makes our reading of it a prudent interpretation.

where Q_{ijc} and P_{ijc} are the quantity and price (online or offline), respectively, of brand i of product j in country c, X_{ij} is a vector of product-specific characteristics ([57]), Y_c is a vector of country-specific control variables (e.g. mean household income and operating costs ([58])) and D_c, D_i, D_j are vectors of dummies capturing country-specific, brand-specific, and product-specific features, respectively. The idea of the estimation of the demand curve (5) is to use an interaction term breaking the base elasticity to offline prices a_2, and separately estimating the difference a_3 between this and that of the corresponding online channel. Also, since prices and quantities are normally endogenous in demand estimations, equation (4) is used to instrument prices so as to get consistent estimates: namely, prices P_{ijc} in model (5) are replaced by their predictions based on (4), which correspond to hedonic (quality-adjusted) prices, independent of the respective quantities. While this is done for each product brand in the referenced source, Table IV.14 below reports the pooled estimation for the prices elasticities offline a_2 and online (a_2+a_3), providing an "average" EU-wide impact of quality-adjusted prices on quantities.

Table IV.14: **Estimated log-linear demand equation for eCommerce goods**

VARIABLES	(log) quantity
	FE
(log) price (*instrumented*)	-0.162***
	(-0.008)
(log) price*Online dummy	-0.276***
	(-0.002)
(log) income	1.154***
	(-0.13)
(log) operating costs	-0.118
	(-0.113)
Observations	222,515
R-squared	0.174
Number of countries	21

(1) The estimation includes country, product, and brand fixed-effects. Prices are instrumented by predictions from a hedonic price regression. Robust standard errors in parentheses. Constant term included. * significant at 10%; ** significant at 5%; *** significant at 1%. The coefficient on "(log) price*Online dummy" equals the (offline-online) price elasticity.
Source: Based on Duch-Brown and Martens (2014)

The results indicate a significantly higher price elasticity of demand for goods sold online, and point to lower and less dispersed prices (and higher competition) in online trade. The estimated demand equation allows to quantify the policy shock in terms of consumer welfare related to the actually observed evolution in consumers' expenditure for online and offline traded goods in the Member States, based on the Hausman (1997) and Brynjolfsson (1995) approximation of Hausman (1981) closed-form solution for the compensating variation ([59]), which only requires the change in expenditure and the online and offline price elasticities of demand. A *caveat* to take into account in this computation, reported in Table IV.15 below, is the fact that the estimated price elasticity is equally applied to all Member States. The observed policy change, in the absence of a more specific measure of the reform effort ([60]), is represented by the observed increase in firms' turnover shares of eCommerce in total

([57]) These product-specific characteristics, controlled for in order to estimate quality-adjusted hedonic prices, include, among the others, the energy efficiency for domestic appliances, and objective features like the colour and the size. Just to provide an example, in the case of washing machines, the estimation controls for: energy efficiency, revolutions per minute, loading, automatic functions, and drying function.

([58]) The inclusion of these country-specific variables (constant across products) imply that the country dummies should capture all further country-specific features, such as the level of competition and consumers' preferences. The correlation between these two set of variables has been controlled for.

([59]) See Duch-Brown and Martens (2014)

([60]) It applies also to this Section what said in Section IV.2 on e-skills: further analysis should better link the outcome variable in terms of prices and quantities of eCommerce with a more specific variable, whose change directly quantifies the reform effort.

Table IV.15: **Impact on consumer surplus (competition channel) from eCommerce reforms (observed)**

Country	Turnover share of eCommerce (2009)	Turnover share of eCommerce (2012)	Estimated impact on consumer surplus (in % of GDP, annual increase)
AT	4.95%	5.65%	0.82%
BE	3.88%	7.60%	1.45%
BG	0.53%	3.54%	2.16%
CY	0.04%	0.09%	1.70%
CZ	8.63%	9.39%	1.90%
DE	9.84%	11.96%	0.88%
DK	3.94%	5.01%	0.39%
EE	7.15%	5.73%	2.93%
EL	1.50%	2.60%	0.02%
ES	1.94%	2.07%	0.85%
FI	6.91%	7.92%	0.90%
FR	3.54%	5.54%	0.95%
HU	1.89%	1.68%	1.37%
IE	1.43%	11.09%	1.46%
IT	0.28%	0.50%	1.13%
LT	6.87%	4.32%	2.30%
LV	0.90%	11.73%	3.37%
NL	12.94%	9.30%	0.40%
PL	1.98%	6.75%	2.82%
PT	4.66%	5.84%	1.21%
RO	1.81%	3.39%	2.95%
SE	7.14%	4.25%	1.24%
SI	2.31%	6.15%	2.67%
SK	1.14%	6.31%	4.89%
UK	4.98%	8.97%	1.03%
EU27	**5.41%**	**6.87%**	**1.13%**

(1) Data for LU and MT are missing.
Source: Eurostat (e-turn) and own computations

retailing ([61]), which increased from 5.4% to 6.9% EU-wide over 2009-2012. On this basis, the mentioned approach allows to straightforwardly compute a policy shock on consumer surplus, expressed a percentage of GDP, related to the chosen outcome variable proxying the reform effort in the field of eCommerce.

Overall, the findings indicate an impact of 1.13% GDP p.a. of consumer surplus over 2009-2012 EU-wide, due to the price effect related to more widespread recourse to eCommerce in the Member States. This impact is a lower-bound approximation, in that it fails to account for: i) the potential price pressure exerted on offline prices by (lower) online prices, coupled with faster shift of EU transactions from the offline to the online channel; ii) the increase in the variety of available final goods, likely to further raise consumers' surplus.

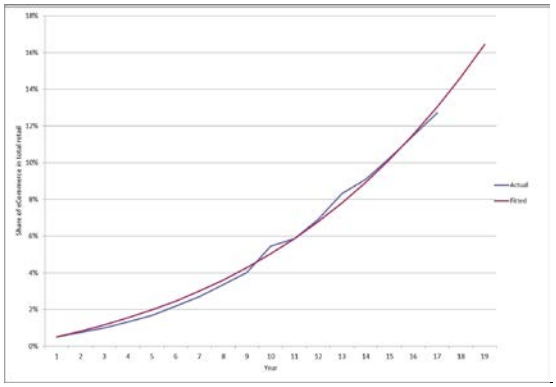
As far as further reform effort to deepen the EU internal market for eCommerce is concerned, the approach to estimating its economic impact, transmitted through the considered competition

([61]) Please note that, for this computation, figures from Eurostat on the percentage of firms' turnover from eCommerce in the retail sector (based on firms with at least 10 employees) are taken into account (E_turn). Resorting to these figures provide two points in time to compare, namely 2009 and 2012. For a few Member States, the missing actual shares have been replaced with an estimation based on the country-specific share of eCommerce in total trade and on the weight of retailing in total trade, under the assumption that the evolution of wholesale one did not significantly differ from it.

channel, is slightly different. Namely, based on the estimations in Civit Consulting (2011) –see Chapter III-, we compute an average reduction in the retail prices of the final goods sector due to deeper integration of the internal market for eCommerce, starting from country-specific price reductions for seven broad categories of final goods sold online, which would be observed if consumers in each Member State could purchase these goods online at the lowest available price EU-wide ([62]). The overall price shock is thus obtained, for each Member State, as the weighted average of the estimated decreases in online prices for all considered product categories, with weights given by their value share in total national retailing.

However, since the impact of the further eCommerce-related reform efforts is expected to deliver over time, an evolution process is considered for the national baseline shares of eCommerce. Namely, the evolution of the retailing shares of e-sales is modelled as a logistic process ([63]), as for other adoption phenomena. Graph IV.7 below shows the best interpolated logistic fit in a least-squares sense for the hysteresis curve of adoption in an "average" Member State, based on actual time series for a sufficiently representative sample ([64]). Based on the interpolated "baseline" evolution of e-retailing, it is thus possible to forecast the future shares of eCommerce in each Member State, for instance as of 2015, starting from the latest actually observed share.

Graph IV.7: **Interpolated logistic fit of national evolution of eCommerce share in total retail (based on 2008-2012 data)**



Source: Commission Services

Based on the mentioned computations, Table IV.16 below reports: i) the current share of e-retailing based on Civit Consulting (2011), and the projected one in 2015, based on the estimated logistic process for eCommerce adoption; ii) the average reduction in online prices for seven broad categories of final goods sold online, due to a more integrated internal market for eCommerce; iii) the related policy shock, expressed as a p.p. reduction in the average retail price for the final goods sector, computed by the Commission Services. This provides a *prima facie* approximation of the direct economic impact of further efforts to foster eCommerce, in line with the DAE targets, through the hereby considered competition channel.

([62]) Own calculations based on Civit Consulting (2011). Due to data availability, country-specific average price shocks have been computed only for 16 Member States, while for 11 other the EU average price shock by Civit Consulting (2011) has been used. This computation would have been possible also based on the database on electronic appliances in Duch-Brown and Martens (2014), but assuming a homogeneous behaviour across products in terms of price reduction would have been unrealistic.

([63]) Thanks are due to the *Directorate General for Communications Networks, Content & Technology* for this computation. It is worth noting that this is based on different figures on baseline eCommerce shares (from the *European Centre of Retail Research*) than Eurostat turnover shares, which have been taken into account in the aforementioned impact on consumer surplus. This allows to include also SMEs, but is characterized by lower geographical and time coverage. The robustness of the previous estimations of the impact on consumer surplus of observed eCommerce reform effort has thus been checked against the use of the new source of data. As expected, the correlation among the results in the two cases is close to 0.98.

([64]) The fit is built by considering the different countries' values for eCommerce shares as if they were extracted from the same process at different points in time: in other words, similar values were attributed to the same year of development even if for different countries they might refer to different years over 2008-2012. This way, one can reconstruct the logistic evolution for a sufficient number of years and forecast growth for the subsequent ones.

Table IV.16: **Impact on prices (competition channel) from eCommerce reforms (further potential)**

Country	E-retailing share in total retailing (2010)	Projected e-retailing share in total retailing (2015)	Average online price shock	Reduction in final goods sector prices (p.p.)
AT	1.10%	3.50%	-25.46%	0.23
BE	2.10%	5.20%	-26.27%	0.34
BG	0.30%	2.10%	n.a.	0.09
CY	3.50%	7.60%	n.a.	0.41
CZ	3.40%	7.50%	-20.66%	0.28
DE	7.10%	13.50%	-24.51%	0.82
DK	5.40%	10.80%	-21.92%	0.42
EE	0.30%	2.10%	n.a.	0.11
EL	0.70%	2.60%	-22.52%	0.19
ES	1.40%	4.00%	-25.00%	0.26
FI	4.00%	8.50%	n.a.	0.37
FR	4.50%	9.30%	-29.92%	0.66
HU	1.10%	3.50%	n.a.	0.24
IE	1.60%	4.40%	n.a.	0.21
IT	3.40%	7.50%	-26.90%	0.56
LT	1.10%	3.50%	n.a.	0.26
LU	3.50%	7.60%	n.a.	0.1
LV	0.80%	3.00%	n.a.	0.2
MT	3.50%	7.60%	n.a.	0.29
NL	3.50%	7.60%	-29.28%	0.43
PL	2.30%	5.60%	-5.89%	0.13
PT	0.80%	3.00%	-21.45%	0.16
RO	0.70%	2.60%	-25.07%	0.19
SE	4.00%	8.50%	-23.46%	0.33
SI	1.80%	4.70%	n.a.	0.27
SK	0.80%	3.00%	-21.31%	0.19
UK	13.50%	23.40%	-10.61%	0.61
EU27	3.50%	7.60%	-21.20%	0.53

Source: Civit Consulting (2011) and Boston Consulting Group (2011) for DE, FR, IT and UK. Missing data for CY, LU, and MT are replaced by the EU27 average on the baseline

Once again, this price effect should be regarded as a lower-bound approximation, in that it fails to take into account: i) the potential price pressure exerted on offline prices by (lower) online ones, coupled with faster shift of EU transactions from the offline to the online channel; ii) the increase in the variety of available final goods in a borderless online market, likely to further raise consumers' surplus; iii) the impact of reforms increasing eCommerce take-up over and above its "baseline" evolution, which, in the absence of more precise information, could be quantified only on the basis of a generic "*closing the gap*" approach (e.g. reducing by a certain amount the distance in terms of eCommerce growth between each Member State and the best EU performer, i.e. the UK).

IV.3.2. QUEST III simulations

In Section IV.3.1, the direct policy shocks, related to already observed or further expected structural reform efforts to deepen the EU internal market for eCommerce, have been quantified as follows: i) a permanent increase in economy-wide TFP due to an *efficiency effect* of higher take-up of e-sales among firms: this amounts to 0.07% and 0.9%, respectively for the already undertaken and the further foreseen reform effort; ii) an increase in consumer surplus by 1.1% of GDP p.a. over 2009-2012 due to a *competition effect* resulting from the observed expansion of e-trade over this period; iii) a reduction in the average retail price of the final goods sector by 0.53 p.p. due to a *competition effect* capturing the competitive downward pressure on prices exerted by higher uptake of eCommerce.

The economy-wide GDP impact of these direct policy shocks (except the impact on consumer surplus, not foreseen by the DSGE model) has been simulated through *QUEST III*. Namely, as for the shock on final goods prices (based on the

Table IV.17: **ECommerce policies – efficiency effect (observed). GDP impacts by countries in % deviation from the baseline**

Years	1	2	3	4	5	10	20	Long-run
AT	0	0	0	0	0	0	0	0
BE	0	0	0	0	0	0	0	0
BG	0.01	0.02	0.02	0.03	0.04	0.09	0.11	0.15
CY	0	0	0.01	0.01	0.01	0.03	0.03	0.04
CZ	0.03	0.04	0.05	0.06	0.08	0.16	0.22	0.39
DE	0	0.01	0.01	0.01	0.01	0.02	0.02	0.04
DK	0	0	0	0	0	0	0	0
EE	0.01	0.01	0.02	0.02	0.03	0.06	0.07	0.09
EL	0	0	0	0	0	0	0	0
ES	0	0.01	0.01	0.01	0.02	0.04	0.04	0.08
FI	0.01	0.02	0.02	0.02	0.03	0.06	0.07	0.11
FR	0	0	0	0	0	0	0	0
HU	0.01	0.02	0.03	0.04	0.04	0.09	0.11	0.14
IE	0.02	0.02	0.03	0.04	0.05	0.1	0.11	0.16
IT	0	0.01	0.01	0.01	0.02	0.04	0.05	0.08
LT	0	0	0	0	0	0	0	0
LU	0.01	0.01	0.02	0.02	0.03	0.05	0.06	0.08
LV	0.01	0.01	0.02	0.03	0.03	0.07	0.08	0.11
MT	0	0	0	0	0.01	0.01	0.02	0.02
NL	0	0	0	0	0	0	0	0
PL	0.01	0.02	0.02	0.03	0.04	0.08	0.09	0.14
PT	0	0	0	0	0	0	0	0
RO	0	0	0	0	0	0	0	0
SE	0.01	0.01	0.02	0.02	0.03	0.06	0.08	0.13
SI	0.02	0.03	0.04	0.05	0.06	0.13	0.16	0.23
SK	0.02	0.04	0.05	0.07	0.09	0.2	0.24	0.33
UK	0.02	0.03	0.03	0.05	0.06	0.12	0.15	0.2
EU27	**0.01**	**0.01**	**0.01**	**0.01**	**0.02**	**0.04**	**0.05**	**0.07**

Source: QUEST III simulations

estimated price effect of past and future reform efforts in eCommerce, and on the current differential online-offline prices), a corresponding reduction in the mark-ups of the final goods sector is computed by scaling down the online price effects with the baseline national shares of eCommerce in total retail (the weights for this policy shock) assuming constant marginal costs. The productivity and mark-up shocks are then phased in over 10 years, to account for possible implementation delays. Table IV.17 and IV.18 show the simulated GDP impacts ([65]), respectively for past and the future efforts. The EU-wide GDP gain for already observed effort is close to 0.1% of GDP, plus a cumulated impact of more than 3% of GDP in terms of consumer surplus. The simulated GDP gain from additional structural reform efforts deepening the EU internal market for eCommerce amounts to some 0.8% over 10 years and up to 1.9% in the long-run, ranging from 0.94% in DK to 2.87% in IT.

([65]) For seven Member States (AT, BE, DK, LT, NL, PT, and RO), whose policy shock is negative, no simulations have been performed, and a zero impact has been reported.

Table IV.18: **Ecommerce policies, competition effect (projected). GDP impacts by countries in % deviation from the baseline**

Years	1	2	3	4	5	10	20	Long-run
AT	0.1	0.14	0.18	0.23	0.3	0.67	0.91	1.67
BE	0.1	0.13	0.16	0.21	0.25	0.54	0.71	1.48
BG	0.13	0.18	0.24	0.31	0.4	0.87	1.1	1.7
CY	0.13	0.23	0.31	0.41	0.53	1.13	1.42	2.05
CZ	0.06	0.1	0.13	0.16	0.19	0.44	0.65	1.26
DE	0.12	0.17	0.21	0.26	0.32	0.67	0.91	1.5
DK	0.04	0.09	0.11	0.13	0.16	0.35	0.47	0.94
EE	0.13	0.17	0.21	0.27	0.34	0.74	0.92	1.35
EL	0.12	0.17	0.23	0.3	0.37	0.85	1.16	2.38
ES	0.11	0.15	0.2	0.25	0.33	0.72	0.98	2.07
FI	0.13	0.17	0.21	0.25	0.31	0.64	0.82	1.49
FR	0.12	0.21	0.29	0.36	0.45	0.96	1.28	2.55
HU	0.11	0.18	0.25	0.33	0.42	0.9	1.09	1.7
IE	0.12	0.13	0.15	0.19	0.23	0.48	0.61	1.04
IT	0.12	0.21	0.3	0.39	0.5	1.11	1.51	2.87
LT	0.14	0.18	0.23	0.29	0.36	0.77	0.96	1.35
LU	0.13	0.17	0.21	0.26	0.33	0.69	0.84	1.43
LV	0.11	0.18	0.26	0.34	0.44	0.95	1.19	1.76
MT	0.11	0.16	0.2	0.27	0.34	0.72	0.89	1.3
NL	0.13	0.17	0.22	0.26	0.33	0.68	0.86	1.38
PL	0.13	0.2	0.27	0.35	0.44	0.9	1.1	1.77
PT	0.11	0.15	0.19	0.25	0.3	0.68	0.89	1.5
RO	0.12	0.19	0.25	0.32	0.41	0.93	1.24	2.19
SE	0.04	0.08	0.11	0.14	0.17	0.37	0.53	0.96
SI	0.12	0.16	0.21	0.27	0.34	0.73	0.92	1.53
SK	0.12	0.17	0.22	0.29	0.36	0.8	1.04	1.66
UK	0.13	0.21	0.26	0.32	0.38	0.76	1	1.53
EU27	**0.12**	**0.18**	**0.24**	**0.3**	**0.37**	**0.78**	**1.04**	**1.89**

Source: QUEST III simulations

IV.4. THE ECONOMIC IMPACT OF FIXED BROADBAND POLICIES ([66])

The DAE aims, among other objectives, to enhance fast and ultra-fast fixed Internet access, above all by guaranteeing universal broadband coverage and increasing speeds, also through the deployment of Next Generation Access (NGA) networks, broad take-up by final users, and an open and neutral Internet. In line with these objectives, the Member States have undertaken ambitious reforms in terms of fixed broadband (see Box IV.4), both supporting infrastructural development through actual public funding and enhancing framework conditions to foster deployment and take-up (including broadband mapping, infrastructure registration and sharing, co-investment measures, administrative streamlining, and standard development).

([66]) Thanks are due to Hagsten Eva, for sharing up-to-date estimations, to Giannakouris Konstantinos for data support, and to Papa Gianluca and Munisteri Filippo for advice on this Section.

Box IV.4: DIGITAL AGENDA MEASURES FOSTERING HIGH-SPEED FIXED BROADBAND

The DAE includes the following measures, mostly undertaken, aimed to enhance fast and ultra-fast Internet access:

1) Key action 8: Adopt in 2010 a Broadband Communication that lays out a common framework for actions at EU and Member State level to meet the Europe 2020 broadband targets, including: i) reinforcing and rationalising, in this framework, the funding of high-speed broadband through EU instruments (e.g. ERDF, ERDP, EAFRD, TEN, CIP) by 2014 and exploring how to attract capital for broadband investments through credit enhancement backed by the EIB and EU funds (undertaken); ii) proposing an ambitious European Spectrum Policy Programme in 2010 for decision by the European Parliament and the Council that will create a co-ordinated and strategic spectrum policy at EU level in order increase the efficiency of radio spectrum management and maximise the benefits for consumers and industry (undertaken); iii) issue a Recommendation in 2010 to encourage investment in competitive NGA through clear and effective regulatory measures (undertaken).

2) Key actions by the Member States: i) developing and making operational national broadband plans by 2012 that meet the coverage and speed and take-up targets defined in Europe 2020, using public financing in line with EU competition and state aid rules, with the Commission annually reporting on progress as part of the Digital Agenda governance (pending with ongoing monitoring); ii) taking measures, including legal provisions, to facilitate broadband investment, such as making sure that civil engineering works systematically involve potential investors, clearing rights of way, mapping available passive infrastructure suitable for cabling and upgrading in-building wiring (pending); iii) fully using the Structural and Rural Development Funds that are already earmarked for investment in ICT infrastructures and services (pending); implementing the European Spectrum Policy Programme, so as to ensure the co-ordinated allocation of the spectrum needed to meet the target of 100% coverage of 30mbps internet by 2020, and the NGA Recommendation (pending).

Example of measures undertaken by some Member States to spur broadband deployment and uptake, which should be considered also in the light of other measures (see Box IV.2) to increase e-skills and digital literacy among citizens and firms, include the following:

Italy: Various reforms have been implemented in Italy over the past years in terms of broadband investments, mostly under the policy framework provided by the Digital Agenda for Europe. Namely, a national strategy was adopted in 2012 for the extension of broadband to rural and isolated areas, where the coverage is still below the EU average. Also, the *National Broadband Plan* included in the March 2012 *Italian Digital Agenda* and the December 2012 Strategic plan both provide a common framework for the granting of public funds by local authorities to high-speed broadband investments, mainly NGA networks, including structural funds where available. Other adopted measures with the same objective of incentivising roll-out also facilitated NGA wiring in jointly-owned parts of a building. These reforms were marked by the country's slight progress in different broadband indicators, although it still lags behind under different respects. For instance, in spite of the progress over 2012 and 2013, overall fixed broadband penetration was still 6.5% lower than the EU average (29.8%) as of beginning-2014. The same applies to NGA coverage (20.8%, compared to an EU average of 61.8% as of end-2013) and take-up (below 1%, compared to a EU average of 8%) respectively the worst and the third worst in the EU, despite progress especially over 2012-2013.

IV.4.1. Identified transmission channels and partial-equilibrium results

In line with the existing literature on the economic impact of both physical availability and actual use and uptake of broadband, outlined in Chapter III, the present Section focuses only on a specific transmission channel, through which structural reform efforts to foster fixed broadband across the EU can exert their economic impact: namely, an

efficiency effect of the use of broadband among firms on economy-wide TFP, which has been tested in previous literature. Instead, a second transmission channel, related to the further *capital deepening effect* of these measures, though not tested due to data limitations, is simulated with *QUEST III* (see Section IV.4.2), thanks to the features of the DSGE model and based on the findings by Analysys Mason (2013) and Tech4i2 (2013).

In terms of the mentioned *efficiency effect*, the analysis in Eurostat (2008) –see Chapter III- indicates a positive productivity impact of higher use of high-speed broadband by workers, over and above that from the mere availability of ICT infrastructure. Namely, the most conservative among the reported findings indicate that an increase by 10 p.p. in the percentage of employees with access to fast broadband is associated on average with an increase in TFP by 0.8%.

Despite the *caveats* ([67]) to take into account in this approach, as already for the case of eCommerce (see Section IV.3.1), the mentioned estimate is used to obtain a *prima facie* approximation of the direct policy shock (namely a productivity shock) stemming from actually observed EU-wide reform efforts incentivizing broadband take-up ([68]): indeed, broadband take-up among employees EU-wide slightly increased over time, from 93% in 2010 to 95% in 2012. This is reported in Table IV.19 below as a percentage increase in TFP. The same approach is also used to quantify the efficiency effect of further efforts to increase broadband penetration in line with the DAE targets: indeed, these foresee that all Europeans should have access to basic broadband by 2013 and to fast broadband by 2020, with at least 50% penetration of ultra-fast one. Unfortunately, in the absence of a structural model distinguishing also among different speed ranges for broadband take-up among workers, it is not possible to have a more refined estimation of the expected productivity shock from the use of high-speed broadband among employees ([69]). Instead, only the full-access target with respect to basic-broadband is taken into account: while this is normally evaluated with reference to households, it is reasonable to assume that, at least in terms of broadband access, it applies also to firms' employees. Therefore, Table IV.19 also reports the impact in terms of TFP of further reform effort spurring basic broadband access among employees up to 100% in line with the DAE key performance target.

Overall, the findings indicate that the observed progress in terms of broadband use over 2010-2012 is associated with a TFP increase of 0.17%, whereas a further 0.42% increase would be associated with further reform effort ensuring at least basic broadband access to all workers.

It is worth noting that the chosen semi-elasticity of TFP to broadband use is supported also by further empirical evidence at sectoral level (services and manufacturing) in Hagsten (2013), which, based on a pooled panel of firms over 2001-2009, also indicates a significant relationship between TFP and broadband penetration among employees, holding for numerous Member States (including AT, DE, FI, FR, IT, LU, NL, NO, SE, and UK): this is summarised in Graph IV.8 below, Indeed, the weighted average of the significant economy-wide elasticities of TFP to broadband use is again close to 0.08, despite sizeable cross-country variability.

([67]) The most evident problematic issue is represented by the use of a weighted average of the estimated elasticities of TFP to broadband use for different Member States, in light of the significant heterogeneity observed across countries. However, the arguments already used for the case of eCommerce (see Section IV.3.1) apply also here.

([68]) However, further analysis should aim to better link reform efforts and outcomes in terms of increased broadband penetration.

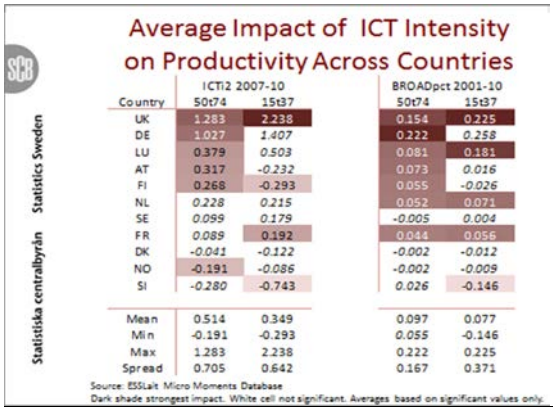
([69]) The fact that the available estimates only refer to a generic definition of broadband, without distinguishing among speed ranges is a caveat to take into due account. Since the most relevant DAE targets for the future actually refer to high-speed broadband, further research should single out the impact on TFP of high-speed broadband take-up. In the absence of these figures, hereby refer only to one of the DAE key performance targets: this is especially relevant for SMEs, in that large companies tend to use connections hooking them directly to the backbone, thus overcoming problems related to local access.

Table IV.19: **Fixed broadband policies – efficiency effect (observed and projected)**

Country	% of employees connecting to Internet via fixed broadband		TFP impact (% change) from observed effort	TFP impact (% change) from further effort (DAE target)
	end-2010	end-2012		
AT	89	94	0.42%	0.50%
BE	96	97	0.08%	0.25%
BG	75	85	0.83%	1.25%
CY	94	98	0.33%	0.17%
CZ	94	97	0.25%	0.25%
DE	93	93	0.00%	0.58%
DK	90	96	0.50%	0.33%
EE	94	97	0.25%	0.25%
EL	92	77	-1.25%	1.91%
ES	97	98	0.08%	0.17%
FI	97	99	0.17%	0.08%
FR	98	99	0.08%	0.08%
HU	92	95	0.25%	0.42%
IE	93	95	0.17%	0.42%
IT	91	96	0.42%	0.33%
LT	84	97	1.08%	0.25%
LU	93	98	0.42%	0.17%
LV	80	94	1.16%	0.50%
MT	96	96	0.00%	0.33%
NL	96	98	0.17%	0.17%
PL	85	91	0.50%	0.75%
PT	91	94	0.25%	0.50%
RO	70	78	0.66%	1.83%
SE	96	98	0.17%	0.17%
SI	94	99	0.42%	0.08%
SK	92	95	0.25%	0.42%
UK	96	98	0.17%	0.17%
EU27	93	95	0.17%	0.42%

Source: Eurostat and own calculations

Graph IV.8: **Estimated TFP impact of broadband use in services and manufacturing**



Source: Hagsten (2013)

IV.4.2. QUEST III simulations

The previous Section discussed a specific transmission channel for reform efforts fostering fixed broadband across the EU, namely an *efficiency effect* capturing the impact on economy-wide TFP of measures incentivising broadband penetration. The obtained findings include: i) a productivity (TFP) shock by 0.17% EU-wide, related to the observed progress in terms of broadband use over 2010-2012; ii) a productivity (TFP) shock of 0.42% related to further efforts ensuring that all workers have at least basic broadband access.

As far as the already observed reform effort is concerned, Table IV.20 below reports the economy-wide GDP impacts corresponding to the estimated productivity shock, simulated through *QUEST III* on the basis of a permanent ([70]) increase in TFP by 0.17%. Overall, the simulations point to an expected EU-wide long-run impact of 0.17% of GDP over the baseline, ranging from less than 0.1% in NL, to 0.67% in BG.

([70]) To the aim of the simulations, the TFP shock is assumed to be permanent, in that the broadband capacity and the associated knowledge investment is reasonably maintained over time. No simulations are performed for EL, as the policy shock is negative.

Table IV.20: **Fixed broadband policies – efficiency effect (observed). GDP impacts by countries in % deviation from baseline**

Years	1	2	3	4	5	10	20	Long-run
AT	0.02	0.03	0.06	0.08	0.11	0.24	0.45	0.61
BE	0	0.01	0.02	0.02	0.03	0.06	0.11	0.14
BG	0.03	0.07	0.11	0.17	0.21	0.48	0.89	1.1
CY	0.02	0.04	0.08	0.1	0.12	0.25	0.47	0.66
CZ	0.02	0.04	0.06	0.08	0.1	0.22	0.4	0.54
DE	0	0	0	0	0	0	0	0
DK	0.02	0.05	0.08	0.11	0.14	0.3	0.52	0.65
EE	0.01	0.03	0.04	0.05	0.07	0.14	0.25	0.29
EL	0	0	0	0	0	0	0	0
ES	0	0.01	0.01	0.02	0.02	0.04	0.08	0.11
FI	0.02	0.02	0.02	0.04	0.04	0.04	0.06	0.09
FR	0.01	0.02	0.03	0.04	0.04	0.09	0.15	0.21
HU	0.01	0.02	0.04	0.06	0.07	0.15	0.26	0.35
IE	0.01	0.02	0.02	0.03	0.04	0.09	0.15	0.18
IT	0.01	0.04	0.06	0.09	0.13	0.27	0.5	0.78
LT	0.04	0.04	0.04	0.09	0.09	0.13	0.22	0.39
LU	0.02	0.07	0.1	0.12	0.17	0.35	0.62	0.84
LV	0.05	0.14	0.21	0.3	0.37	0.79	1.37	1.62
MT	0	0	0	0	0	0	0	0
NL	0.01	0.02	0.03	0.03	0.04	0.08	0.14	0.2
PL	0.02	0.04	0.07	0.09	0.12	0.25	0.44	0.57
PT	0.01	0.02	0.04	0.05	0.06	0.14	0.25	0.33
RO	0.03	0.06	0.09	0.13	0.16	0.33	0.58	0.75
SE	0	0.01	0.02	0.03	0.04	0.07	0.14	0.2
SI	0.05	0.11	0.11	0.16	0.21	0.42	0.84	1.42
SK	0.01	0.02	0.03	0.04	0.05	0.13	0.24	0.32
UK	0.01	0.02	0.04	0.05	0.06	0.13	0.24	0.29
EU27	**0**	**0.01**	**0.02**	**0.02**	**0.03**	**0.07**	**0.13**	**0.17**

Source: QUEST III simulations

As far as further reform efforts are concerned, not only the GDP impacts of the mentioned productivity shock are simulated with *QUEST III* but a further *capital deepening effect* is included in the simulations. This captures, within the DSGE model, the impact, namely the externality effect on private investments, of public investment policies, for instance those stimulating broadband roll-out both by direct funding and by soft measures to decrease deployment costs such as broadband mapping, co-investment measures, infrastructure registration and sharing, administrative streamlining, and standard development ([71]).

In detail, the impact of measures fostering digital infrastructure through large-scale fixed broadband investments is simulated in *QUEST III* with reference to two types of measures: i) direct government subsidies to private telecommunication companies (called *direct intervention*), to reduce firms' capital cost requirements and thereby stimulate private investments; ii) various regulatory and non-regulatory measures leading to savings in deployment costs (called *indirect intervention*). The related policy shocks have been computed by the Commission Services on the basis of Analysys Mason (2013), distinguishing two scenarios in terms of public intervention: i) a modest scenario, where measures fostering broadband are proxied by a 5% reduction in deployment costs (*indirect intervention*) and by the availability of 7bn EUR for infrastructural investments ([72]), in particular in

([71]) This kind of measures has been recently considered by the Commission. See, for instance, the 2010 NGA Recommendation, the European Commission *Proposal for a Regulation on measures to reduce the cost of deploying high-speed electronic communications networks* (COM/2013/0147) and the *Recommendation on consistent non-discrimination obligations and costing methodologies to promote competition and enhance the broadband investment environment* - C(2013) 5761.

([72]) Please, note that this amount is in line with the CEF original proposal, while the final decision was to assign 850mn to digital services (in the form of grants), of which 150mn for broadband deployment (in financial instruments).

FTTP ([73]), allocated to the Member States proportionally to the current gap in NGA coverage left by the market (*direct intervention*); ii) an *ambitious* scenario, where measures fostering broadband are proxied by a 10% reduction in relevant deployment costs (*indirect intervention*) and by the availability, in each Member State, of the needed public funding to ensure broadband (in particular FTTP) deployment to meet the DAE target for 100Mbit/s capable services. Tables IV.21 and IV.22 below report the monetary values, expressed as a percentage of GDP, of the additional private investments induced by the hypothesised (direct and indirect) reform effort in the EU in terms of public support to infrastructural investments and cost-saving measures for broadband roll-out: this impact on private ICT capital has been computed ([74]) as the difference between private investments in the baseline scenario and, respectively, the modest and ambitious scenarios analysed by Analysys Mason (2013).

The tables indicate that direct and indirect measures incentivizing broadband roll-out in line with the DAE targets should entail additional private investments worth between 0.014% and 0.058% of EU GDP (in a modest and ambitious scenario, respectively). To the aim of the present work, this capital deepening shock is considered as a further effect, on top of the previously estimated increase in TFP by 0.42%, of further reform efforts in terms of broadband deployment and uptake (including ensuring full penetration of basic broadband among employees). The related GDP impacts, simulated through *QUEST III*, are reported in Tables IV.23 and IV.24 below: namely, the capital deepening shock is modelled as a temporary productivity impact ([75]), in that new public and private ICT infrastructure is *de facto* created for free, i.e. without the budgetary implications of having to be financed through additional labour tax revenue. The policy shocks have been phased in over a period of, respectively, 15 years in the modest scenario and 10 years in the ambitious scenario, in order to take into account the factual absorption capacity of the concerned Member States ([76]). In each Member State, the interventions have been scaled into the model according to their percentage share in national GDP.

Overall, the simulation results for the modest and the ambitious scenarios of further reform efforts show similar EU-wide GDP impacts, mainly differing in terms of their speed: namely, the overall impact amounts to between 0.18% and 0.32% of GDP relative to the baseline over 10 years, and to some 0.43% in the long-run.

([73]) Fibre-To-The-Premises (FTTP) is a technology for providing Internet access by running fibre optic cable directly from an Internet Service Provider (ISP) to a user's home or business and can refer either to Fibre-To-The-Home (FTTH), where fibre goes directly into individual houses, or to Fibre-To-The-Building or Basement (FTTB), where the fibre goes to the building and from there splits off to multiple subscribers within the building via non-optical connections. FTTP is considered one of the most "future proof" types of broadband Internet technology, since there are no foreseeable devices that could use more bandwidth than can be sent via fibre optic cables.

([74]) Calculations performed by the Directorate General for Communications Networks, Content & Technology.

([75]) Whereas the TFP shock is assumed to be permanent, in that the broadband capacity and associated knowledge investment is maintained overtime, the temporary nature of the cost-reduction (and productivity enhancing) effect is a consequence of the assumption that the DAE targets be achieved, which limits in time the possibility to resort to further cost-reducing measures.

([76]) Here, the output elasticity of public capital (infrastructure) is assumed to be 0.1, following Gramlich (1994), in both scenarios.

Table IV.21: **Fixed broadband policies - capital deepening effect: further private investments (in GDP %) - modest scenario**

Years	1	2	3	4	5	6	7	8	9	10
AT	0.07	0.011	0.013	0.014	0.014	0.013	0.011	0.009	0.006	0.004
BE	0	0	0	0	0	0	0	0	0	0
BG	0.027	0.01	0.013	0.015	0.014	0.012	0.002	0.009	0.021	0.018
CY	0	0.021	0.02	0.021	0.023	0.026	0.028	0.025	0.02	0.031
CZ	0.016	0.026	0.029	0.015	0.015	0.014	0.031	0.022	0.018	0.019
DE	0.03	0.014	0.015	0.017	0.018	0.017	0.015	0.011	0.008	0.005
DK	0.044	0.01	0.01	0.009	0.008	0.007	0.005	0.004	0.003	0.002
EE	0.036	0.02	0.024	0.021	0.018	0.015	0.013	0.009	0.006	0.004
EL	0.003	0.023	0.028	0.027	0.03	0.032	0.041	0.042	0.039	0.045
ES	0.022	0.038	0.043	0.048	0.05	0.051	0.067	0.059	0.042	0.032
FI	0.051	0.019	0.019	0.02	0.02	0.02	0.017	0.015	0.011	0.007
FR	0.045	0.033	0.038	0.042	0.04	0.039	0.036	0.031	0.026	0.029
HU	0.043	0.023	0.025	0.026	0.031	0.02	0.02	0.031	0.047	0.024
IE	0.002	0.015	0.017	0.017	0.017	0.016	0.028	0.022	0.018	0.016
IT	0.002	0.012	0.01	0.011	0.015	0.018	0.018	0.016	0.013	0.012
LT	0.079	0.01	0.01	0.01	0.009	0.008	0.008	0.005	0.004	0.005
LU	0.001	0	0	0	0	0	0	0	0	0
LV	0.089	0.009	0.011	0.011	0.011	0.01	0.01	0.012	0.014	0.007
MT	0	0.003	0.004	0.006	0.009	0.01	0.01	0.008	0.005	0.004
NL	0	0	0	0	0	0	0	0	0	0
PL	0.028	0.032	0.035	0.035	0.032	0.051	0.035	0.044	0.019	0.018
PT	0.007	0.004	0.004	0.006	0.006	0.007	0.007	0.005	0.004	0.002
RO	0.007	0.028	0.032	0.032	0.036	0.031	0.03	0.063	0.091	0.071
SE	0.043	0.032	0.032	0.051	0.059	0.05	0.038	0.029	0.02	0.013
SI	0	0	0	0.001	0.001	0.001	0.001	0.001	0.001	0
SK	0.042	0.01	0.006	0.007	0.009	0.011	0.011	0.011	0.009	0.009
UK	0.008	0.009	0.011	0.012	0.013	0.013	0.013	0.01	0.007	0.008
EU27	**0.023**	**0.018**	**0.02**	**0.022**	**0.023**	**0.023**	**0.023**	**0.02**	**0.016**	**0.014**

Source: Analysys Mason (2013) and own calculations based on DG ECFIN's potential GDP projections

Table IV.22: **Fixed broadband policies – capital deepening effect: further private investments (in GDP %) – ambitious scenario**

Years	1	2	3	4	5	6	7	8	9	10
AT	0.168	0.159	0.155	0.161	0.143	0.121	0.098	0.073	0.049	0.034
BE	0.002	0.001	0.001	0.002	0.002	0.003	0.003	0.002	0.002	0.001
BG	0.178	0.185	0.2	0.198	0.179	0.151	0.069	0.099	0.165	0.138
CY	0.001	0.381	0.404	0.392	0.359	0.405	0.367	0.331	0.239	0.195
CZ	0.041	0.221	0.257	0.22	0.211	0.185	0.202	0.145	0.108	0.088
DE	0.064	0.159	0.171	0.163	0.159	0.134	0.117	0.086	0.061	0.039
DK	0.107	0.163	0.155	0.136	0.133	0.105	0.08	0.059	0.043	0.029
EE	0.052	0.04	0.037	0.034	0.028	0.03	0.03	0.022	0.015	0.01
EL	0.006	0.34	0.494	0.556	0.58	0.57	0.54	0.483	0.364	0.289
ES	0.032	0.093	0.104	0.17	0.218	0.211	0.192	0.151	0.11	0.086
FI	0.131	0.472	0.485	0.42	0.523	0.509	0.416	0.31	0.246	0.191
FR	0.062	0.076	0.093	0.099	0.096	0.089	0.125	0.129	0.092	0.074
HU	0.085	0.087	0.092	0.093	0.099	0.078	0.066	0.085	0.11	0.061
IE	0.005	0.223	0.225	0.211	0.197	0.173	0.162	0.13	0.094	0.069
IT	0.005	0.109	0.099	0.105	0.118	0.111	0.102	0.089	0.069	0.063
LT	0.174	0.104	0.095	0.081	0.068	0.057	0.048	0.033	0.026	0.023
LU	0.026	0.011	0.012	0.011	0.011	0.01	0.009	0.007	0.006	0.005
LV	0.321	0.319	0.335	0.313	0.286	0.234	0.213	0.173	0.14	0.087
MT	0	0.006	0.008	0.013	0.019	0.022	0.022	0.017	0.012	0.008
NL	0	0	0	0	0	0	0	0	0	0
PL	0.06	0.161	0.182	0.197	0.217	0.25	0.189	0.177	0.097	0.076
PT	0.047	0.045	0.051	0.057	0.063	0.059	0.056	0.05	0.038	0.027
RO	0.012	0.107	0.141	0.15	0.137	0.113	0.097	0.143	0.181	0.141
SE	0.056	0.079	0.169	0.178	0.222	0.185	0.159	0.122	0.081	0.051
SI	0.002	0.039	0.045	0.05	0.06	0.068	0.065	0.051	0.038	0.028
SK	0.192	0.225	0.226	0.241	0.24	0.219	0.189	0.156	0.108	0.082
UK	0.02	0.075	0.08	0.101	0.091	0.086	0.075	0.062	0.045	0.044
EU27	**0.045**	**0.114**	**0.126**	**0.134**	**0.14**	**0.128**	**0.12**	**0.101**	**0.074**	**0.058**

Source: Analysys Mason (2013) and own calculations based on DG ECFIN's potential GDP projections

Table IV.23: **Fixed broadband policies (modest scenario) – GDP impacts by countries in % deviation from baseline**

Years	1	2	3	4	5	10	20	Long-run
AT	0.02	0.09	0.15	0.11	0.14	0.29	0.54	0.73
BE	0.01	0.03	0.05	0.08	0.1	0.2	0.35	0.45
BG	0.04	0.1	0.18	0.25	0.33	0.73	1.34	1.65
CY	0.01	0.03	0.05	0.06	0.08	0.14	0.25	0.34
CZ	0.02	0.04	0.07	0.09	0.11	0.23	0.41	0.54
DE	0.02	0.04	0.06	0.08	0.1	0.2	0.35	0.45
DK	0.02	0.04	0.06	0.08	0.1	0.2	0.34	0.43
EE	0.01	0.03	0.05	0.06	0.08	0.15	0.25	0.29
EL	0.03	0.08	0.13	0.19	0.25	0.55	1.05	1.55
ES	0.02	0.03	0.05	0.06	0.07	0.11	0.18	0.24
FI	0.01	0.02	0.02	0.03	0.03	0.03	0.03	0.04
FR	0.01	0.03	0.04	0.06	0.07	0.1	0.16	0.22
HU	0.02	0.05	0.08	0.11	0.13	0.26	0.45	0.58
IE	0.02	0.04	0.06	0.08	0.11	0.21	0.37	0.44
IT	0.01	0.04	0.06	0.08	0.1	0.21	0.4	0.61
LT	0.01	0.01	0.02	0.02	0.02	0.03	0.05	0.09
LU	0.01	0.03	0.04	0.06	0.07	0.14	0.25	0.34
LV	0.03	0.06	0.1	0.13	0.17	0.35	0.59	0.7
MT	0.01	0.03	0.05	0.07	0.09	0.18	0.31	0.38
NL	0.01	0.02	0.03	0.03	0.04	0.08	0.14	0.21
PL	0.03	0.08	0.12	0.16	0.2	0.39	0.67	0.86
PT	0.02	0.04	0.07	0.1	0.13	0.27	0.5	0.65
RO	0.07	0.17	0.27	0.37	0.47	0.97	1.64	2.09
SE	0.01	0.02	0.04	0.05	0.06	0.09	0.15	0.2
SI	0.01	0.02	0.03	0.04	0.04	0.09	0.16	0.28
SK	0.02	0.04	0.06	0.08	0.1	0.21	0.4	0.53
UK	0.01	0.03	0.04	0.06	0.07	0.14	0.24	0.29
EU27	**0.02**	**0.04**	**0.06**	**0.08**	**0.09**	**0.18**	**0.32**	**0.43**

Source: QUEST III simulations

Table IV.24: **Fixed broadband policies (ambitious scenario) – GDP impacts by countries in % deviation from baseline**

Years	1	2	3	4	5	10	20	Long-run
AT	0.06	0.13	0.18	0.23	0.28	0.48	0.57	0.74
BE	0.03	0.06	0.09	0.13	0.16	0.3	0.35	0.46
BG	0.1	0.23	0.35	0.48	0.6	1.18	1.39	1.65
CY	0.09	0.18	0.23	0.27	0.3	0.35	0.33	0.35
CZ	0.06	0.14	0.2	0.24	0.28	0.41	0.45	0.54
DE	0.04	0.1	0.14	0.18	0.21	0.33	0.38	0.45
DK	0.05	0.11	0.15	0.18	0.21	0.34	0.36	0.44
EE	0.04	0.07	0.1	0.12	0.14	0.23	0.26	0.3
EL	0.12	0.28	0.42	0.55	0.66	1.04	1.18	1.52
ES	0.04	0.08	0.12	0.15	0.18	0.22	0.21	0.25
FI	0.1	0.2	0.25	0.27	0.29	0.23	0.13	0.04
FR	0.03	0.07	0.1	0.12	0.14	0.19	0.18	0.22
HU	0.05	0.1	0.15	0.19	0.24	0.42	0.47	0.59
IE	0.04	0.11	0.15	0.19	0.23	0.37	0.39	0.44
IT	0.04	0.09	0.13	0.17	0.21	0.36	0.42	0.61
LT	0.03	0.05	0.06	0.07	0.08	0.07	0.07	0.09
LU	0.03	0.05	0.08	0.1	0.13	0.22	0.26	0.35
LV	0.12	0.22	0.29	0.36	0.41	0.62	0.65	0.7
MT	0.03	0.06	0.09	0.12	0.15	0.27	0.32	0.39
NL	0.02	0.03	0.05	0.06	0.07	0.12	0.14	0.21
PL	0.09	0.18	0.27	0.35	0.42	0.67	0.72	0.87
PT	0.04	0.09	0.14	0.18	0.23	0.43	0.51	0.65
RO	0.14	0.31	0.47	0.63	0.78	1.5	1.68	2.09
SE	0.04	0.08	0.11	0.14	0.16	0.18	0.18	0.2
SI	0.02	0.05	0.07	0.09	0.1	0.15	0.18	0.28
SK	0.07	0.13	0.19	0.23	0.27	0.4	0.45	0.54
UK	0.03	0.06	0.1	0.12	0.15	0.24	0.26	0.3
EU27	**0.04**	**0.09**	**0.13**	**0.17**	**0.2**	**0.32**	**0.35**	**0.43**

Source: QUEST III simulations

V. CONCLUDING REMARKS

This work aims to assess the economic impact of structural reforms either already undertaken or imminently foreseen in Europe in the field of digital markets. In fact, even more so in the wake of the economic crisis, the policy debate on how to spur "digital growth" in Europe has thus become increasingly topical, and ambitious digital structural reforms have been either undertaken by the Member States or foreseen for the imminent future in line with the broad policy agenda set by the *Digital Agenda for Europe* (DAE) and with the European Semester exercise. This debate also hinges upon the well-acknowledged economic relevance of electronic communications and, more broadly, digital networks and services, which goes well beyond their mere sectoral size and, in light of their role as general purpose technology, encompasses a series of positive spill-overs exerted upon the whole productive system.

Assessing digital structural reforms in a unitary framework is challenging, due to a variety of reasons ranging from the marked heterogeneity of these reforms, their mostly "soft" nature, as well as a general lack of data on different aspects of EU digital markets. For these reasons, only four specific types of digital structural reforms are considered in this work, namely: i) assigning rights of use of radio spectrum frequencies to mobile operators; ii) enhancing digital skills in a professional setting; iii) fostering the take-up of eCommerce; iv) increasing availability and take-up of high-speed fixed broadband. Since these policy areas are markedly different, each of them is analysed separately, yet following a common twofold methodological approach, which represents the main value added of this work with respect to previous estimations on the same topic.

As a first step, namely, partial equilibrium econometric analysis –mostly at sectoral level– is carried out, or drawn from existing literature, to estimate a direct impact of a relevant "reform variable", proxying each Member State's digital reform effort, on either prices or productivity. These economic outcomes directly affected by the reform effort are, in fact, assumed to be the "transmission channels", through which the scrutinised reforms can finally exert their overall economic impact. In particular:

- progress in spectrum assignment is found to be associated with lower retail prices for mobile services, including indirectly through decreased sectoral market concentration;

- enhanced digital skills in a professional setting are found to be associated with higher intra-sectoral allocative efficiency of resources in the economy, likely due to the better capacity of firms to react to changes in the competitive environment;

- increased take up of eCommerce EU-wide is found to be associated to higher total factor productivity, due to the enhanced efficiency of the production process entailed by firms' recourse to online sales, and to lower final goods prices, due to competitive pressures in online trade;

- increased take-up of high-speed fixed broadband is found to be associated with higher TFP, due to the increased efficiency in the production process related to the firms' actual use of these technologies.

As a second step, the estimated elasticity from the first step and the observed variation of the reform variable are used to compute a price/productivity shock related to the considered digital reform effort, either already observed or foreseen for the future. A further step includes feeding the estimated shocks into the European Commission's dynamic stochastic general equilibrium model *QUEST III* in order to obtain macroeconomic impacts on GDP growth: while the analysis is conducted separately for each policy area, the advantage of considering them together lies in the possibility to add up the long-run GDP impacts and thereby provide a unitary indication of the overall effect of achieving specific aspects of the Digital Single Market. Not least, in simulating the economic impact of further reform efforts in line with the DAE targets, the use of a DSGE model allows to take into account further transmission channels that data availability issues prevent from being econometrically tested, such as the impact of capital deepening. Graph V.1 below summarises, for all analysed policy areas, the identified transmission channel(s), the outcome variable(s) found to be directly affected by them, the type of shock(s) fed into *QUEST III*, and the simulated

Graph V.1: **Summary table of reform areas, tested transmission channels and direct economic impact**

Structural Reform area	Economic outcome variable directly affected	Transmission channels tested through econometric analysis	Partial equilibrium estimation of observed policy changes in EU27	Simulated GDP impact (already achieved from actually observed effort)	Simulated GDP impact of closing the gap with the Digital Agenda for Europe targets
Assigning Radio Spectrum Frequencies	Final retail price of mobile voice services	Impact of increased assignment of radio spectrum frequencies on sectoral retail prices, both direct (through innovation) and indirect (through reduced market concentration)	Average decrease in sectoral prices between 21% and 22% EU-wide due to observed spectrum progress between 2007 and 2013	0.2% long-run	0.3% - 0.4% long-run
	Capital deepening	Only simulated through QUEST: leverage effect on private capital of deepened public capital due to spectrum revenues, and efficiency effects due to measures reducing deployment costs	N.A.	N.A.	
Enhancing professional e-skills	Intra sectoral allocative efficiency	Impact of increased sectoral share of ICT skilled employment on allocative efficiency	0.65 p.p. average increase in sectoral allocative efficiency (and close to 0.5 p.p. increase in labour productivity) EU-wide	0.6% long-run	0.4% long-run
Reinforcing the integration of the Digital Single Market and e-business models	Total factor productivity and final prices (mark-ups and consumer surplus)	Impact of increased recourse to e-sales among firms on productivity and impact on consumer surplus of higher recourse to e-sales (through a competition effect).	Average increase in TFP by 0.07% over 2010-2012 and increase in consumer surplus by 1.3% GDP p.a. over 2009-2012	0.1% long-run (plus the impact on consumer surplus)	1.9% long-run
Incentivizing fixed broadband deployment	Total factor productivity	Impact of increased use of broadband technologies in a professional setting on firm-level productivity and thereby on TFP	TFP increase by 0.17% due to more broadband take-up among workers	0.2% long-run	0.43% long-run
	Capital deepening	Only simulated through QUEST: externality effects of private capital increase due to public incentives and efficiency effects due to measures reducing deployment costs	N.A.	N.A.	

Source: Own calculations

long-run impact(s) on EU GDP. Overall, the findings highlight the significant growth potential of both the already observed efforts and of further ambition in terms of digital structural reforms. Namely, Table V.1 and V.2 below report the overall country-specific GDP impacts, respectively for the past and the future reform efforts in all of the four analysed policy areas; all impacts refer to the maximum achievable (ambitious scenario). Overall, these findings highlight that the already observed reform effort in the four considered policy fields correspond to a long-run GDP impact of some 1% over the baseline; besides, further foreseen structural reform efforts in the four policy areas could entail additional GDP increase of up to 3.1% over the baseline in the long run. Last but not least, these findings are relevant from a methodological viewpoint, in that the present work hints at the importance of analysing the actual functioning of the microeconomic transmission channels, through which digital structural reforms could exert their overall macroeconomic impact.

Table V.1: **Combined effects of selected DAE measures (observed). GDP impacts by countries in % deviation from baseline**

Years	1	2	3	4	5	10	20	Long-run
AT	0.19	0.3	0.41	0.51	0.62	0.81	1.14	1.63
BE	0.23	0.43	0.57	0.7	0.85	0.94	1.1	1.67
BG	0.17	0.28	0.37	0.5	0.6	0.98	1.47	1.94
CY	0.14	0.23	0.34	0.41	0.49	0.67	0.94	1.29
CZ	0.09	0.16	0.22	0.27	0.34	0.57	0.85	1.29
DE	0.14	0.24	0.32	0.41	0.47	0.55	0.64	0.9
DK	0.16	0.29	0.41	0.51	0.62	0.84	1.14	1.53
EE	0.31	0.51	0.68	0.84	1.02	1.25	1.5	1.97
EL	0.08	0.13	0.16	0.2	0.23	0.27	0.34	0.6
ES	0.06	0.13	0.17	0.22	0.27	0.37	0.48	0.88
FI	0.29	0.45	0.57	0.72	0.86	0.98	1.12	1.7
FR	0.02	0.03	0.05	0.07	0.08	0.15	0.23	0.39
HU	0.14	0.24	0.35	0.45	0.51	0.7	0.9	1.26
IE	0.04	0.05	0.07	0.1	0.13	0.25	0.34	0.49
IT	0.07	0.15	0.21	0.29	0.37	0.59	0.9	1.5
LT	0.16	0.23	0.31	0.43	0.48	0.58	0.73	1.08
LU	0.19	0.34	0.46	0.59	0.71	0.98	1.33	1.85
LV	0.14	0.28	0.4	0.55	0.64	1.17	1.81	2.24
MT	0.13	0.2	0.27	0.34	0.42	0.47	0.54	0.72
NL	0.02	0.03	0.05	0.06	0.08	0.14	0.22	0.35
PL	0.11	0.19	0.27	0.35	0.42	0.63	0.88	1.26
PT	0.08	0.14	0.21	0.27	0.33	0.48	0.67	1
RO	0.09	0.16	0.23	0.3	0.37	0.61	0.93	1.34
SE	0.18	0.29	0.42	0.52	0.63	0.78	0.98	1.37
SI	0.15	0.26	0.31	0.41	0.51	0.82	1.3	2.1
SK	0.09	0.16	0.2	0.27	0.32	0.55	0.73	1.04
UK	0.32	0.51	0.71	0.89	1.06	1.32	1.59	2.06
EU27	**0.13**	**0.19**	**0.28**	**0.34**	**0.41**	**0.53**	**0.68**	**1.00**

Source: QUEST III simulations

Table V.2: **Combined effects of selected DAE measures (further potential). GDP impacts by countries in % deviation from baseline**

Years	1	2	3	4	5	10	20	Long-run
AT	0.71	1.24	1.52	1.73	1.94	2.69	3.2	4.66
BE	0.31	0.46	0.58	0.71	0.82	1.31	1.59	2.76
BG	0.45	0.76	1.05	1.35	1.66	3.03	3.59	4.77
CY	0.41	0.69	0.86	1.04	1.23	1.99	2.34	3.24
CZ	0.29	0.53	0.69	0.8	0.92	1.44	1.79	2.81
DE	0.35	0.55	0.68	0.82	0.95	1.49	1.84	2.69
DK	0.22	0.39	0.5	0.59	0.7	1.06	1.24	1.96
EE	0.34	0.46	0.56	0.67	0.8	1.34	1.61	2.25
EL	0.47	0.79	1.04	1.29	1.51	2.55	3.16	5.26
ES	0.34	0.5	0.64	0.76	0.92	1.47	1.8	3.31
FI	0.41	0.63	0.77	0.88	1.01	1.35	1.5	2.35
FR	0.32	0.51	0.65	0.78	0.92	1.56	1.92	3.45
HU	0.3	0.49	0.67	0.84	1.02	1.84	2.16	3.13
IE	0.34	0.48	0.58	0.69	0.8	1.27	1.46	2.11
IT	0.35	0.58	0.76	0.93	1.12	1.98	2.53	4.45
LT	0.32	0.41	0.5	0.6	0.71	1.15	1.37	1.9
LU	0.33	0.45	0.55	0.67	0.8	1.28	1.51	2.4
LV	0.4	0.68	0.9	1.09	1.28	2.1	2.45	3.29
MT	0.31	0.44	0.54	0.67	0.82	1.36	1.64	2.27
NL	0.38	0.52	0.65	0.75	0.86	1.31	1.56	2.33
PL	0.38	0.61	0.84	1.06	1.27	2.07	2.39	3.48
PT	0.38	0.59	0.74	0.89	1.04	1.7	2.07	3.11
RO	0.46	0.79	1.06	1.33	1.62	3.12	3.67	5.35
SE	0.22	0.36	0.48	0.59	0.68	0.95	1.18	1.77
SI	0.32	0.52	0.67	0.8	0.94	1.47	1.77	2.77
SK	0.37	0.62	0.82	1	1.16	1.9	2.31	3.33
UK	0.3	0.47	0.62	0.74	0.87	1.4	1.7	2.41
EU27	**0.36**	**0.54**	**0.7**	**0.84**	**0.98**	**1.59**	**1.96**	**3.14**

Source: QUEST III simulations

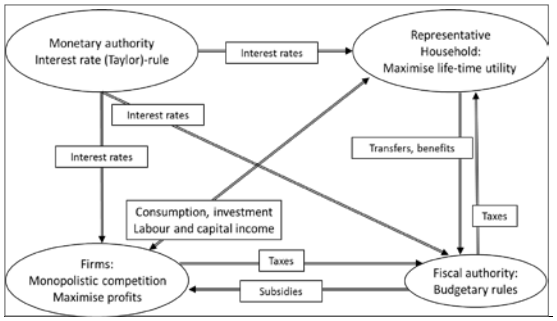
ANNEX 1
Description of the QUEST III model

The simulation exercise presented in this paper is based on the semi-endogenous growth version of the *QUEST III* model, specifically adapted for the analysis of structural reforms ([77]). Its multi-country setup allows analysing the spill-over effects when simultaneous reforms in all countries are considered. In resorting to *QUEST III* to simulate the macro impacts of selected digital structural reforms, particular attention is devoted to mirroring the underlying micro-foundations that characterise the present analysis.

The details of the model follow: Graph Annex1.1 and Graph Annex1.2 below provide an intuitive description of the functioning of the model economy, which is populated by households, final and intermediate goods producing firms, a research industry, a monetary and a fiscal authority. In the final goods sector firms produce differentiated goods which are imperfect substitutes for goods produced abroad. Final good producers use a composite of intermediate goods and three types of labour (low-, medium-, and high-skilled). Households buy the patents of designs produced by the R&D sector and license them to the intermediate goods producing firms. The intermediate sector is composed of monopolistically competitive firms which produce intermediate products from rented capital input using the designs licensed from the household sector. The production of new designs takes place in research labs, employing high skilled labour and making use of the existing stock of ideas. Technological change is modelled as increasing product variety in the tradition of Dixit & Stiglitz (1977).

([77]) This follows the endogenous growth version of QUEST III (RD) model-structure of Roeger et al. (2008) in a multi-country setting (D'Auria F. et al, 2010), and includes all 27 individual member states of the EU and the rest of the world as a separate region. For euro area member states, the model takes into account the lack of independent monetary policy in the euro area wide Taylor-rule.

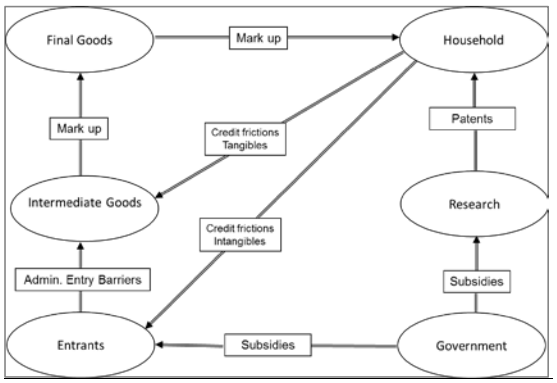
Graph Annex1.1: **Functioning of the QUEST III model**



Source: Commission Services

The model economy is populated by households, final and intermediate goods producing firms, a research industry, a monetary and a fiscal authority. In the final goods sector firms produce differentiated goods which are imperfect substitutes for goods produced abroad. Following the semi-endogenous growth model of Jones (1995, 2005), technological change is modelled as increasing product variety in the tradition of Dixit & Stiglitz (1977). Final good producers use a composite of intermediate goods and three types of labour - low-, medium-, and high-skilled. Non-liquidity constrained households buy the patents of designs produced by the R&D sector and license them to the intermediate goods producing firms. The intermediate sector is composed of monopolistically competitive firms which produce intermediate products from rented capital input using the designs licensed from the household sector. The production of new designs takes place in research labs, employing high skilled labour and making use of the existing stock of ideas.

Graph Annex1.2: **Functioning of the QUEST III model**



Source: Commission Services

Households

The household sector consists of a continuum of households $h \in [0,1]$. A share $(1-\varepsilon)$ of these households is not liquidity constrained and indexed by $i \in [0, 1-\varepsilon]$. They have access to financial markets where they can buy and sell domestic assets (government bonds), accumulate physical capital which they rent out to the intermediate sector, and they also buy the patents of designs produced by the R&D sector and license them to the intermediate goods producing firms. ([78]) The remaining share ε of households is liquidity constrained and indexed by $k \in (1-\varepsilon, 1]$. These households cannot trade in financial and physical assets and consume their disposable income each period. For each skill group we assume that households (liquidity and non-liquidity constrained) supply differentiated labour services to unions which act as wage setters in monopolistically competitive labour markets. The unions pool wage income and distribute it in equal proportions among their members. Nominal rigidity in wage setting is introduced by assuming that the households face adjustment costs for changing wages.

Non-liquidity constrained households

Non-liquidity constrained households maximise an intertemporal utility function in consumption and leisure subject to a budget constraint. These households make decisions about consumption

($C_{i,t}$), and labour supply ($L_{i,s,t}$), the purchases of investment good ($J_{i,t}$) and government bonds ($B_{i,t}$), the renting of physical capital stock ($K_{i,t}$), the purchases of new patents from the R&D sector ($J_{A,i,t}$), and the licensing of existing patents ($A_{i,t}$), and receive wage income ($W_{s,t}$), unemployment benefits ([79]) ($bW_{s,t}$), transfer income from the government ($TR_{i,t}$), and interest income (i_t, $i_{K,t}$ and $i_{A,t}$). Hence, non-liquidity constrained households face the following Lagrangian

$$\max_{\left\{\begin{matrix} C_{i,t}, L_{i,s,t}, B_{i,t} \\ J_{i,t}, K_{i,t} \\ J_{A,i,t}, A_{i,t} \end{matrix}\right\}_{t=0}^{\infty}} V_{i,0} = E_0 \sum_{t=0}^{\infty} \beta^t \left(U(C_{i,t}) + \sum_{s \in \{L,M,H\}} V(1-L_{i,s,t}) \right)$$

$$- E_0 \sum_{t=0}^{\infty} \lambda_{i,t} \frac{\beta^t}{P_t} \begin{pmatrix} (1+t_{C,t}) P_{C,t} C_{i,t} + B_{i,t} + P_{I,t}\left(J_{i,t} + \Gamma_J(J_{i,t})\right) + P_{A,t} J_{A,i,t} \\ -(1+i_{t-1}) B_{i,t-1} \\ -\sum_s (1-t_{w,s,t}) W_{s,t} L_{i,s,t} - bW_{s,t}(1-NPART_{i,s,t} - L_{i,s,t}) \\ -(1-t_K)(i_{K,t-1} - rp_K) P_{I,t-1} K_{i,t-1} - t_K \delta_K P_{I,t-1} K_{i,t-1} - \tau_K P_{I,t} J_{i,t} \\ -(1-t_K)(i_{A,t-1} - rp_A) P_{A,t-1} A_{i,t-1} - t_K \delta_A P_{A,t-1} A_{i,t-1} - \tau_A P_{At} J_{A,i,t} \\ -TR_{i,t} - \sum_{j=1}^{N} PR_{fin,j,i,t} - \sum_{m=1}^{A_t} PR_{\text{int},m,i,t} \end{pmatrix} \quad (1)$$

$$- E_0 \sum_{t=0}^{\infty} \lambda_{i,t} \xi_{i,t} \beta^t \left(K_{i,t} - J_{i,t} - (1-\delta_K) K_{i,t-1} \right) - E_0 \sum_{t=0}^{\infty} \lambda_{i,t} \psi_{i,t} \beta^t \left(A_{i,t} - J_{A,i,t} - (1-\delta_A) A_{i,t-1} \right)$$

where s is the index for the corresponding low- (L), medium- (M) and high-skilled (H) labour type respectively ($s \in \{L,M,H\}$). The budget constraints are written in real terms with the price for consumption, investment and patents ($P_{C,t}$, $P_{I,t}$, $P_{A,t}$) and wages ($W_{s,t}$) divided by GDP deflator (P_t). All firms of the economy are owned by non-liquidity constrained households who share the total profit of the final and intermediate sector firms, $\sum_{j=1}^{N} PR_{fin,j,i,t}$ and $\sum_{m=1}^{A_t} PR_{\text{int},m,i,t}$, where N and A_t denote the number of firms in the final and intermediate sector respectively. As shown by the budget constraints, all households pay consumption taxes ($t_{C,t}$), wage income taxes ($t_{w,s,t}$) and t_K capital income taxes less tax credits (τ_K and τ_A) and depreciation allowances ($t_K \delta_K$ and $t_K \delta_A$) after their earnings on physical capital and patents. When investing into tangible and intangible capital the household requires premium rp_K and rp_A in order to cover the increased risk on the return related to these assets.

The utility function is additively separable in consumption ($C_{i,t}$) and leisure ($1-L_{i,s,t}$). We assume log-utility for consumption and allow for habit persistence.

$$U(C_{i,t}) = (1-habc) \log\left(C_{i,t} - habc C_{t-1}\right) \quad (2)$$

([78]) It is important to note that in a semi-endogenous model the number of intermediate goods varieties (At) can be interpreted in multiple ways. It corresponds to the total number of designs (or patents) invented by the R&D sector but at the same time it can be interpreted as the stock of ideas or as the stock of knowledge (or intangible) capital in the economy. Also, as shown in Appendix B, it can be considered as an endogenous total factor productivity element.

([79]) Households only make a decision about the level of employment but there is no distinction on the part of households between unemployment and non-participation. It is assumed that the government makes a decision how to classify the non-working part of the population into unemployed and non-participants. The non-participation rate (NPART) must therefore be seen as a policy variable characterising the generosity of the benefit system.

We assume CES preferences with common elasticity but a skill specific weight (ω_s) on leisure. This is necessary in order to capture differences in employment levels across skill groups. Thus preferences for leisure are given by

$$V(1-L_{i,s,t}) = \frac{\omega_s}{1-\kappa}(1-L_{i,s,t})^{1-\kappa} \qquad (3)$$

with $\kappa > 0$. The investment decisions w.r.t. real capital are subject to convex adjustment costs, which are given by

$$\Gamma_J(J_{i,t}) = \frac{\gamma_K}{2}\frac{(J_{i,t})^2}{K_{i,t-1}} + \frac{\gamma_I}{2}(\Delta J_{i,t})^2 \qquad (4)$$

The first order conditions of the household with respect to consumption, financial and real assets are given by the following equations:

$$\frac{\partial V_0}{\partial C_{i,t}} => U_{C,i,t} - \lambda_{i,t}(1+t_{C,t})\frac{P_{C,t}}{P_t} = 0 \qquad (5a)$$

$$\frac{\partial V_0}{\partial B_{i,t}} => -\lambda_{i,t} + E_t\left(\lambda_{i,t+1}\beta(1+i_t)\frac{P_t}{P_{t+1}}\right) = 0 \qquad (5b)$$

$$\frac{\partial V_0}{\partial K_{i,t}} => E_t\left(\lambda_{i,t+1}\frac{\beta P_{I,t}}{P_{t+1}}\left((1-t_K)(i_{K,t}-rp_K)+t_K\delta_K\right)\right) - \lambda_{i,t}\xi_{i,t} + E_t\left(\lambda_{i,t+1}\xi_{i,t+1}\beta(1-\delta_K)\right) = 0 \qquad (5c)$$

$$\frac{\partial V_0}{\partial J_{i,t}} => -\left(\left(1+\gamma_K\left(\frac{J_{i,t}}{K_{i,t-1}}\right)+\gamma_I\Delta J_{i,t}\right)-\tau_K\right) + E_t\left(\frac{1}{1+i_t}\frac{P_{I,t+1}}{P_{I,t}}\gamma_I\Delta J_{i,t+1}\right) + \xi_{i,t}\frac{P_t}{P_{I,t}} = 0 \qquad (5d)$$

Non-liquidity constrained households buy new patents of designs produced by the R&D sector

($I_{A,t}$) and rent their total stock of design (A_t) at rental rate $i_{A,t}$ to intermediate goods producers in period *t*. Households pay income tax at rate t_K on the period return of intangibles and they receive tax subsidies at rate τ_A. Hence, the first order conditions with respect to R&D investments are given by

$$\frac{\partial V_0}{\partial A_{i,t}} => E_t\left(\lambda_{i,t+1}\frac{\beta P_{A,t}}{P_{t+1}}\left((1-t_K)(i_{A,t}-rp_A)+t_K\delta_A\right)\right) - \lambda_{i,t}\psi_{i,t} + E_t\left(\lambda_{i,t+1}\psi_{i,t+1}\beta(1-\delta_A)\right) = 0 \qquad (6a)$$

$$\frac{\partial V_0}{\partial J_{A,i,t}} => -\frac{P_{A,t}}{P_t}(1-\tau_A) + \psi_{i,t} = 0 \qquad (6b)$$

Therefore the rental rate can be obtained from (6a), (6b) and (5b):

$$i_{A,t} = E_t\left(\frac{(1-\tau_A)(i_t - \pi_{A,t+1} + \delta_A + \delta_A\pi_{A,t+1}) - t_K\delta_A}{1-t_K}\right) + rp_A \qquad (6c)$$

where $1+\pi_{A,t+1} = \frac{P_{A,t+1}}{P_{A,t}}$.

Equation (6c) states that households require a rate of return on intangible capital which is equal to the nominal interest rate minus the rate of change of the value of intangible assets and also covers the cost of economic depreciation plus a risk premium. Governments can affect investment decisions in intangible capital by giving tax incentives in the form of tax credits and depreciation allowances or by lowering the tax on the return from patents.

Liquidity constrained households

Liquidity constrained households do not optimize but simply consume their current income at each date. Real consumption of household *k* is thus determined by the net wage income plus benefits and net transfers:

$$(1+t_{C,t})P_{C,t}C_{k,t} = \sum_{s\in\{L,M,H\}}\left(\left(1-t_{w,s,t}\right)W_{s,t}L_{k,s,t} + bW_{s,t}(1-NPART_{k,s,t}-L_{k,s,t})\right) + TR_{k,t} \qquad (7)$$

Wage setting

Within each skill group a variety of labour services are supplied which are imperfect substitutes to each other. Thus trade unions can charge a wage mark-up ($1/\eta_{s,t}$) over the reservation wage ([80]). The reservation wage is given as the marginal utility of leisure divided by the corresponding marginal utility of consumption. The relevant net real wage to which the mark up adjusted reservation wage is equated is the gross wage adjusted for labour taxes, consumption taxes and unemployment benefits, which act as a subsidy to leisure. Thus the wage equation is given as

$$\frac{U_{1-L,h,s,t}}{U_{C,h,s,t}}\frac{1}{\eta_{s,t}} = \frac{W_{s,t}(1-t_{w,s,t}-b)}{P_{C,t}(1+t_{C,t})} \text{ for } s\in\{L,M,H\} \qquad (8)$$

where *b* is the benefit replacement rate.

Aggregation

([80]) The mark-up depends on the intratemporal elasticity of substitution between differentiated labour services within each skill groups (σ_s) and fluctuations in the mark-up arise because of wage adjustment costs and the fact that a fraction (1-*sfw*) of workers is indexing the growth rate of wages π_W to wage inflation in the previous period $\eta_{s,t} = 1 - 1/\sigma_s - \gamma_W/\sigma_s(\beta(sfw\pi_{W,t+1} - (1-sfw)\pi_{W,t-1}) - \pi_{W,t})$.

The aggregate of any household specific variable $X_{h,t}$ in per capita terms is given by

$$X_t = \int_0^1 X_{h,t}\,dh = (1-\varepsilon)X_{i,t} + \varepsilon X_{k,t} \qquad (9)$$

Hence aggregate consumption and employment is given by

$$C_t = (1-\varepsilon)C_{i,t} + \varepsilon C_{k,t} \qquad (10)$$

and

$$L_t = (1-\varepsilon)L_{i,t} + \varepsilon L_{k,t} \qquad (11)$$

Firms

Final output producers

Since each firm produces a variety of the domestic good which is an imperfect substitute for the varieties produced by other firms, it acts as a monopolistic competitor facing a demand function with a price elasticity given by σ_d. Final output (Y_t) is produced using A_t varieties of intermediate inputs ($x_{m,t}$) with an elasticity of substitution *1/(1-θ) > 1*. The final good sector uses labour aggregate ($L_{Y,t}$) and intermediate goods in a Cobb-Douglas technology, subject to a fixed cost *FC*

$$Y_t = (L_{Y,t})^{\alpha}\left(\sum_{m=1}^{A_t}(x_{m,t})^{\theta}\right)^{\frac{1-\alpha}{\theta}} - FC \qquad (12)$$

with

$$L_{Y,t} = \left(\Lambda_L^{\frac{1}{\mu}}(\chi_L L_{L,t})^{\frac{\mu-1}{\mu}} + \Lambda_M^{\frac{1}{\mu}}(\chi_M L_{M,t})^{\frac{\mu-1}{\mu}} + \Lambda_{HY}^{\frac{1}{\mu}}(\chi_{HY} L_{HY,t})^{\frac{\mu-1}{\mu}}\right)^{\frac{\mu}{\mu-1}} \qquad (13)$$

$L_{L,t}$, $L_{M,t}$ and $L_{HY,t}$ denote the employment of low, medium and high-skilled in final goods production respectively. Parameter Λ_z is the corresponding share parameter $(z \in \{L,M,HY\})$, χ_z is the efficiency unit, and μ is the elasticity of substitution between different labour types. Note that high-skilled workers can work in the final goods and the R&D sector as well, therefore the total number of high-skilled ($L_{H,t}$) should be equal to the number of high-skilled employed in the final goods ($L_{HY,t}$) and in the R&D sector respectively ($L_{RD,t}$):

$$L_{H,t} = L_{HY,t} + L_{RD,t} \qquad (14)$$

In a symmetric equilibrium, the demand for labour and intermediate inputs is given by

$$\alpha\frac{Y_t}{L_{Y,t}}\left(\frac{L_{Y,t}}{L_{z,t}}\right)^{\frac{1}{\mu}}\Lambda_z^{\frac{1}{\mu}}\chi_z^{\frac{\mu-1}{\mu}}\eta = W_{z,t}, \quad z \in \{L,M,HY\} \qquad (15)$$

$$px_{m,t} = \eta(1-\alpha)Y_t\left(\sum_{m=1}^{A_t}(x_{m,t})^{\theta}\right)^{-1}(x_{m,t})^{\theta-1} \qquad (16)$$

where $\eta = 1-1/\sigma_d$ and $px_{m,t}$ is the price of intermediate goods ([81]).

Intermediate goods producers

The intermediate sector consists of monopolistically competitive firms which have entered the market by licensing a design from domestic households and by making an initial payment FC_A to overcome administrative entry barriers. Capital inputs are also rented from the household sector for a rental rate of $i_{K,t}$. Firms which have acquired a design can transform each unit of capital into a single unit of an intermediate input. In a symmetric equilibrium, the respective inverse demand functions of intermediate goods producing firms are given as (16), therefore the first order condition is

$$\theta\eta(1-\alpha)Y_t\left(\sum_{m=1}^{A_t}(x_{m,t})^{\theta}\right)^{-1}(x_{m,t})^{\theta-1} = i_{K,t} \qquad (17)$$

Intermediate goods producers set prices with a mark-up over marginal cost. Therefore intermediate goods prices are given by:

$$px_{m,t} = \frac{i_{K,t}}{\theta} \qquad (18)$$

The no-arbitrage condition requires that entry into the intermediate goods producing sector takes place until

$$PR_{\text{int},m,t} = i_{A,t}P_{A,t} + (i_{A,t} + \pi_{A,t+1})FC_A, \quad \forall m \qquad (19)$$

For an intermediate producer, entry costs consist of the licensing fee $i_{A,t}P_{A,t}$ for the design or patent which is a prerequisite of production of innovative

([81]) Note that η is inversely related to the net mark-ups in the final goods sector (mkp_f): $\eta = 1/(1+ mkp_f)$.

intermediate goods and a fixed administrative entry cost FC_A.

R&D sector

Innovation corresponds to the discovery of a new variety of producer durables that provides an alternative way of producing the final good. The R&D sector hires high-skilled labour ($L_{RD,t}$) and generates new designs according to the following knowledge production function:

$$\Delta A_t = \nu A_{t-1}^{*\,\varpi} A_{t-1}^{\phi} \left(L_{RD,t}\right)^{\lambda} \qquad (20)$$

In this framework we allow for international R&D spillovers following Bottazzi & Peri (2007). Parameters ϖ and ϕ measure the foreign and domestic spillover effects from the aggregate international and domestic stock of knowledge (A^*_t and A_t) respectively. Negative value for these parameters can be interpreted as the "fishing out" effect, i.e. when innovation decreases with the level of knowledge, while positive values refer to the "standing on shoulders" effect and imply positive research spillovers. Note that $\phi = 1$ would yield the strong scale effect feature of endogenous growth models with respect to the domestic level of knowledge. Parameter ν can be interpreted as total factor efficiency of R&D production, while λ measures the elasticity of R&D production on the number of researchers ($L_{RD,t}$). The international stock of knowledge grows exogenously at rate g_{A^*}. We assume that the R&D sector is operated by a research institute which employs high skilled labour at their market wage, $W_{H,t}$. We also assume that the research institute faces an adjustment cost (γ_A) of hiring new employees and maximizes the following discounted profit-stream:

$$\max_{L_{RD,t}} \sum_{t=0}^{\infty} d_t \left(P_{A,t} \Delta A_t - W_{H,t} L_{RD,t} - \frac{\gamma_A}{2} W_{H,t} \left(\Delta L_{RD,t}\right)^2 \right) \qquad (21)$$

where d_t is the discount factor. High-skilled are paid the same wages across sectors: $W_{H,t}$=$W_{HY,t}$

Policy

On the expenditure side we distinguish between government consumption (G_t), government investment (IG_t), government transfers (TR_t) and unemployment benefits (BEN_t), where

$$BEN_t = \sum_{s \in \{L,M,H\}} bW_{s,t} (1 - NPART_{s,t} - L_{s,t}) \qquad (22)$$

The government provides subsidies (SUB_t) on physical capital and R&D investments in the form of a tax-credit and depreciation allowances

$$SUB_t = t_K \left(\delta_K P_{I,t-1} K_{i,t-1} + \delta_A P_{A,t-1} A_{i,t-1}\right) + \tau_K P_{I,t} J_{i,t} + \tau_A P_{A,t} J_{A,i,t}. \qquad (23)$$

Government revenues R_t^G are made up of taxes on consumption as well as capital and labour income. Government debt (B_t) evolves according to

$$B_t = (1 + i_t) B_{t-1} + G_t + IG_t + TR_t + BEN_t + SUB_t - R_t^G \qquad (24)$$

The labour tax ($t_{w,t}$) used for controlling the debt to GDP ratio according to the following rule

$$\Delta t_{w,t} = \tau_B \left(\frac{B_{t-1}}{Y_{t-1}} - b^T \right) + \tau_{DEF} \Delta \left(\frac{B_t}{Y_t} \right) \qquad (25)$$

where τ_B captures the sensitivity with respect to deviations from b^T, the government debt target and τ_{DEF} controls the sensitivity of the tax-rule w.r.t. changes in the debt to output ratio.

Monetary policy is modelled via the following Taylor rule, which allows for some smoothness of the interest rate response (i_t) to the inflation and output gap.

$$i_t = \gamma_{ilag} i_{t-1} + (1 - \gamma_{ilag}) \left(r_{EQ} + \pi_{TAR} + \gamma_{\inf} \left(\pi_{C,t} - \pi_{TAR}\right) + \gamma_{ygap} \hat{y}_t\right) \qquad (26)$$

The central bank has a constant inflation target (π_{TAR}) and it adjusts interest rates whenever actual consumer price inflation $(\pi_{C,t})$ deviates from the target and it also responds to the output gap $(\hat{y}_t)$ via the corresponding $\gamma_{\inf}$ and γ_{ygap} coefficients. There is also some inertia in nominal interest rate setting over the equilibrium real interest rate r_{EQ} determined by γ_{ilag}. Output gap is defined as deviation of capital and labour utilisation from their long run trends. Note that in our multicountry setting, members of the euro area do not have independent monetary policy, we assume that the European Central Bank sets interest rate by taking into account the euro area wide aggregate inflation and output gap changes in its Taylor-rule.

Trade

In order to facilitate aggregation we assume that households, the government and the final goods sector have identical preferences across goods used for private consumption, investment and public expenditure. Let $Z_t \in \{C_t, I_t, G_t, IG_t\}$ be the demand of households, investors or the government as defined in the previous section, then their preferences are given by the following utility function:

$$Z_t = \left((1-\rho)^{\frac{1}{\sigma_{im}}} Z_{d,t}^{\frac{\sigma_{im}-1}{\sigma_{im}}} + \rho^{\frac{1}{\sigma_{im}}} Z_{f,t}^{\frac{\sigma_{im}-1}{\sigma_{im}}} \right)^{\frac{\sigma_{im}}{\sigma_{im}-1}} \qquad (27)$$

where ρ is the share parameter and σ_{im} is the elasticity of substitution between domestic ($Z_{d,t}$) and foreign produced goods ($Z_{m,t}$).

ANNEX 2
Detailed impact on investments

As a consequence of the policy shocks estimated in relation to the structural reforms enhancing wireless and fixed broadband, it was simulated with *QUEST III* that, under the "modest" ("ambitious", respectively) scenario, additional investments could be generated EU-wide in the measure of additional 0.15% (0.53%, respectively) of GDP over 5 years, and of 0.36% of GDP in the long-run, relative to the baseline. Table Annex2.1 and Table Annex2.2 below show these simulated country-specific impacts on investments. It should be remarked that the capital deepening effects of the additional broadband investments are phasing out over time, while the assumed productivity effect of higher broadband penetration remains permanent.

Table Annex2.1: **Fixed and wireless broadband reforms – "modest scenario": additional investment in GDP % by country**

Years	1	2	3	4	5	10	20	Long-run
AT	0.02	0.05	0.07	0.09	0.11	0.21	0.43	0.48
BE	0	0.01	0.02	0.04	0.05	0.13	0.25	0.31
BG	0.03	0.06	0.1	0.14	0.19	0.41	0.92	1.17
CY	0.08	0.17	0.22	0.24	0.26	0.25	0.49	0.43
CZ	0.03	0.06	0.09	0.11	0.13	0.19	0.39	0.44
DE	0.04	0.08	0.11	0.13	0.15	0.23	0.45	0.39
DK	0.02	0.04	0.06	0.07	0.08	0.14	0.28	0.33
EE	0.02	0.04	0.06	0.06	0.07	0.09	0.19	0.21
EL	0.09	0.21	0.32	0.41	0.49	0.78	0.97	0.89
ES	0.08	0.16	0.2	0.22	0.22	0.15	0.21	0.21
FI	0.04	0.07	0.09	0.09	0.09	0.07	0.1	0.08
FR	0.06	0.12	0.15	0.16	0.16	0.11	0.16	0.18
HU	0.06	0.13	0.17	0.2	0.22	0.28	0.47	0.53
IE	0.11	0.24	0.33	0.4	0.45	0.56	0.77	0.5
IT	0.03	0.06	0.09	0.11	0.14	0.21	0.42	0.51
LT	0.03	0.06	0.07	0.08	0.08	0.11	0.21	0.22
LU	0	0.01	0.02	0.03	0.04	0.1	0.24	0.33
LV	0.03	0.05	0.07	0.09	0.11	0.2	0.4	0.45
MT	0.02	0.05	0.08	0.1	0.12	0.19	0.4	0.37
NL	0	0.01	0.03	0.04	0.06	0.13	0.25	0.26
PL	0.07	0.15	0.19	0.23	0.25	0.31	0.59	0.78
PT	0.02	0.04	0.07	0.1	0.12	0.26	0.5	0.48
RO	0.05	0.12	0.17	0.23	0.28	0.45	0.89	1.27
SE	0.06	0.12	0.15	0.16	0.15	0.09	0.17	0.17
SI	0.01	0.02	0.03	0.05	0.07	0.15	0.31	0.33
SK	0.02	0.05	0.07	0.09	0.12	0.21	0.44	0.51
UK	0.03	0.07	0.1	0.11	0.12	0.16	0.31	0.25
EU27	**0.04**	**0.09**	**0.12**	**0.14**	**0.15**	**0.19**	**0.34**	**0.36**

Source: QUEST III simulations

Table Annex2.2: **Fixed and wireless broadband reforms – "ambitious scenario": additional investment in GDP % by country**

Years	1	2	3	4	5	10	20	Long-run
AT	0.16	0.31	0.38	0.4	0.4	0.36	0.45	0.49
BE	0	0.01	0.03	0.05	0.08	0.21	0.27	0.31
BG	0.24	0.47	0.58	0.63	0.66	0.77	0.97	1.17
CY	1.12	2.08	2.36	2.31	2.1	0.54	0.45	0.45
CZ	0.23	0.45	0.55	0.58	0.57	0.39	0.41	0.44
DE	0.26	0.5	0.59	0.6	0.58	0.39	0.45	0.4
DK	0.23	0.42	0.47	0.47	0.43	0.28	0.31	0.33
EE	0.04	0.07	0.09	0.1	0.12	0.17	0.23	0.22
EL	1.13	2.31	2.91	3.11	3.06	1.51	0.76	0.78
ES	0.22	0.45	0.58	0.64	0.65	0.31	0.21	0.21
FI	0.76	1.44	1.66	1.65	1.51	0.38	0.14	0.08
FR	0.15	0.29	0.37	0.4	0.41	0.24	0.18	0.19
HU	0.17	0.34	0.42	0.47	0.49	0.47	0.49	0.53
IE	0.87	1.67	1.93	1.9	1.74	0.79	0.62	0.5
IT	0.16	0.32	0.4	0.45	0.47	0.39	0.44	0.51
LT	0.17	0.29	0.32	0.32	0.3	0.21	0.23	0.22
LU	0.02	0.04	0.06	0.08	0.1	0.19	0.27	0.34
LV	0.34	0.64	0.75	0.76	0.73	0.45	0.44	0.46
MT	0.04	0.09	0.13	0.17	0.21	0.32	0.43	0.38
NL	0	0.01	0.03	0.06	0.09	0.23	0.27	0.27
PL	0.33	0.64	0.79	0.85	0.86	0.62	0.66	0.79
PT	0.11	0.22	0.29	0.34	0.37	0.43	0.52	0.48
RO	0.14	0.3	0.42	0.5	0.56	0.76	0.94	1.27
SE	0.22	0.43	0.53	0.55	0.52	0.21	0.2	0.17
SI	0.09	0.18	0.24	0.28	0.3	0.28	0.32	0.34
SK	0.3	0.58	0.7	0.72	0.7	0.44	0.47	0.51
UK	0.19	0.37	0.45	0.47	0.45	0.29	0.32	0.26
EU27	**0.21**	**0.41**	**0.5**	**0.53**	**0.53**	**0.35**	**0.36**	**0.36**

Source: QUEST III simulations

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