Journal of Evolutionary Economics (2022) 32:553–590
https://doi.org/10.1007/s00191-022-00769-4

REGULAR ARTICLE

The effect of technological behaviour and beliefs on subjective well-being: the role of technological infrastructure

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Accepted: 3 April 2022 / Published online: 18 April 2022

Abstract

The aim of the paper is to investigate the role of technological infrastructures in the relationship between subjective well-being (SWB) and the use of technological goods on the one hand, and between SWB and technological attitudes on the other. We use the sixth wave of the World Value Survey, which allows us to have comparable data for 60 countries over the period 2010–2014. We show that the use of internet as a means of collecting information is associated with different levels of SWB depending on the efficiency of the technological infrastructure. Moreover, we find a positive, though not always statistically significant, association between scientific and technological attitudes and SWB and show that this relation is stronger in areas with less efficient technological structures. The focus on the linkage between technological infrastructure and SWB paves the way for policy interventions aimed at promoting a coherent development of technological access, use and beliefs.

Keywords Subjective well-being · Internet infrastructure · Internet use · Technological beliefs

JEL I31 · O10 · O33

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1 Introduction

The use of technological goods of all types (such as TV, mobile phone, internet) has grown a lot in recent years. According to the Internet World Stats website (https://www.Internetworldstats.com/stats.htm, accessed: 16.02.22), 65.6% of the world population uses the internet, with a growth rate in the last twenty-one years equal to 1,331.9% and a penetration rate (% of population) ranging from 43.2% in Africa (growth rate 13,058%) to 93.9% in North America (growth rate 221.9%; data as of 31 March 2021). This general context has led many to 'compare digital transformation with earlier industrial transformations propelled by general-purpose technologies like steam or electricity' (OECD 2019). The impacts generated by new technological knowledge have been at the core of several theoretical and empirical studies investigating its microeconomic and macroeconomic effects on several economic variables, such as employment (e.g. Harrison et al. 2014; Vivarelli 2014), productivity (e.g. Crowley and McCann 2018; Liang et al. 2010) and growth (e.g. Hasan and Tucci 2010). However, while the effect of technological innovations on the performance of firms or countries has been deeply investigated, much lower importance has been assigned to the impact they may have on the subjective well-being (SWB) of people. In this respect, from a theoretical point of view, Martin (2013) has highlighted that innovation studies are confronted with some crucial social challenges and identified one of the most important as the investigation of the impacts of innovation on measures of well-being. This position is echoed by Binder (2013), who underlines that the uneven nature of innovativeness calls for further investigations of its role in the society's well-being.

From a conceptual point of view, the model proposed by Engelbrecht (2014, 2018) has helped to frame the likely consequences and manifold relationships between technological innovations and employment, environment, social relations and cultural identity, recognising that they can affect SWB in an ambiguous way. In particular, quoting Schubert (2012), he underlines that if innovation studies are not linked to their implications for well-being, they lose their capability to also be relevant from a policy perspective.

In the empirical literature, the nexus between technological knowledge and SWB has mainly focused attention on one of the channels identified by Engelbrecht (2014), that is, the consumption perspective relative to the practical use of technological devices. This theoretical framework is adopted by some macroeconomic studies (e.g. Aldieri et al. 2021; Ganju et al. 2016; Maiti and Awasthi 2020) that have introduced variables accounting for the use of technological goods in the specification of the life-satisfaction equation. However, this topic has also been analysed from a microeconomic perspective, considering the impact on SWB of the TV (Bruni and Stanca 2006, 2008), the smartphone (e.g. Rotondi et al. 2017), the internet and the use of social networks (e.g. Arampatzi et al. 2018; Graham and Nikolova 2013; Sabatini and Sarracino 2017). Despite the technological goods being taken into consideration, this type of literature has generated two contradictory findings. On the one side, authors agree that greater access to technological goods may exert a positive effect on SWB, because it extends the possibilities for contacts and relationships with other people, favours a greater feeling of 'power' over one's personal life and allows people to save time that can be devoted to other

activities. On the other side, relying on technological devices to a greater extent can also adversely affect the quality of life and face-to-face relationships among people, increasing stress and anxiety because of their pervasiveness.

This micro-level approach is the same one that we follow in our study. However, while the literature has mainly concentrated on investigating the effect of the use of technological goods, we introduce, as a further aspect of interest, the role played by technological and scientific beliefs in SWB. These beliefs may reflect different dimensions, such as the subject's acceptance and optimism over the scientific method and reliance on technology and science (Farias et al. 2013; Stavrova et al. 2016). We will refer to reliance on and optimism about the usefulness of progress in science and technology in improving the living conditions of mankind (Stavrova et al. 2016). Only some very limited psychological literature has investigated through which type of mental mechanism, beliefs in science and technology can have an impact on SWB at the individual level. These studies have made use of compensatory control theories according to which people, when they do not feel that they are in control over various domains of their lives (e.g. Bäckman and Dixon 1992), try to restore control by implementing different strategies, among which the belief in technological progress may have a role in filling the void emerging from this perception of the lack of control over life (Landau et al. 2015; Stavrova et al. 2016). Within the innovation literature, this side of the issue has mainly been neglected; only Bhuiyan and Szulga (2017) have provided empirical evidence on the positive effect of technological and scientific attitudes on life satisfaction.

The main value added by the paper is relative to the introduction of the role of technological infrastructures in the relationship between, on the one hand, SWB and the use of technology and, on the other, SWB and personal beliefs about scientific and technological progress.

More specifically, our first contribution stems from focusing on the use of a technological device, namely the internet, and SWB. The use of Internet as an information source may positively affect SWB by providing people with more data in less time and with lower waste of energy in comparison with alternative sources, such as newspapers, TV etc. In fact, people can have a greater access to opportunities among which they can choose, saving time and effort. However, while the effect of the internet on SWB has already been investigated in some studies, which nevertheless have led to mixed results, we propose introducing the role of the ICT infrastructure, which is missing from the framework. Our approach is analogous to that proposed by Lohmann (2015), as we take the broadband penetration rate as a proxy for the quality of the technological infrastructure. However, differently from Lohmann (2015), who showed that a higher quality of internet infrastructure lowers the effect of income on SWB by increasing the level of material aspirations, we examine whether the quality of the technological infrastructure directly affects the relationship between SWB and the intensity of internet use to get information. We think that a more efficient ICT infrastructure could make information (of whatever type) available in a lesser amount of time in greater quantities and varieties, thereby reducing information asymmetries, and could help achieve network externalities within the country, thus making the internet use more valuable.

Our second contribution is to analyse the relationship between SWB and personal beliefs about science and technology and, in particular, to consider the mediating role of technological infrastructure in this relation, which has never been investigated so far. Beliefs in scientific progress might play a compensatory-control function (Rutjens et al. 2010, 2013; Farias et al. 2013; Meijers and Rutjens 2014; Gottlieb et al. 2018), favouring the feeling of control over life which is positively associated with SWB (Creed and Bartrum 2008; Gerstorf et al. 2014; Verme 2009). We hypothesise that where the ICT infrastructure is weaker, the impact on SWB of optimism about the usefulness of scientific and technological progress will be higher. Since technological development and information technology enhance people's capabilities and empowerment by making people richer in terms of potential larger set of choices in life opportunities (Aker and Mbiti 2010; Graham and Nikolova 2013; Castellacci and Tveito 2018), we expect that, in context of lower technological development and weaker technological infrastructure, people may feel more urgently the need of a secondary source of control over their lives.

As we think that the use of technology as well as technological and scientific beliefs can both affect SWB and be affected by the quality of the technological infrastructure, although through different channels, we have included both determinants into the SWB equation. We also underline that the focus of our paper is not the relationship between the two microeconomic variables depicting technological beliefs and use but, rather, the possibility that the relationship of both of them with SWB is mediated by a common macroeconomic variable.

We are also aware that the technological infrastructure may mediate the effect on SWB of other technological aspects, such as the use of different technological devices. We chose to consider the intensity of internet use to retrieve information because it is one of the most pervasive means by which technology affects our life. It is 'incorporated' in almost all of the technological goods we use, such the mobile phone, computer and TV: nowadays, everything is connected through the use of the web. Moreover, as Lohmann (2015) has also pointed out, the internet is inherently different from other technological devices, as the amount of information that passes through the web amplifies the possibility and frequency of interactions among people. Technological infrastructure can also impact on other domains of life, even though we think the effect will be less direct than for technological variables.

The empirical analysis is based on data from the sixth wave of the World Value Survey (WVS). The data set includes 60 countries and covers the years 2010–2014. Given the cross-sectional nature of the dataset the possible endogeneity of the regressors cannot be excluded. For this reason, as better discussed in Section 4.1, our results cannot be interpreted in a causal way but rather as correlations.

The richness of the dataset has allowed us to verify whether the effect may hold for several countries, thus providing evidence of cross-country empirical regularities as well as heterogeneities between and within groups of countries. As other studies have argued, there are some universal determinants of SWB, such as income and health, but others are more specific to some groups of countries (e.g. see Section 2.1). Indeed, countries may have different SWB determinants because of different cultural values that may evolve over time, possibly including experiences with technological goods and scientific knowledge. This may hold also for different expectations that people may have for the future about what advantages and disadvantages technological knowledge may bring them.

We reached two sets of results. On the one hand, we have been able to show that internet use is associated with different levels of SWB depending on the quality of the technological infrastructure. On the other hand, we can highlight a positive, though not always statistically significant, relationship between scientific and technological attitude and SWB and show that this relationship is stronger in areas with less efficient technological infrastructures.

The paper is organised as follows. In Section 2 we review the literature, in Section 3 we propose the main theoretical hypotheses of this study. Section 4 presents the data set and empirical methods. Section 5 focuses on the results obtained. Section 6 concludes by providing some hints for avenues for further research.

2 Related literature

2.1 SWB definition and determinants

The first strand of literature on which the paper is based is the SWB literature, of which the two most important terms used to describe this concept are happiness and life satisfaction. It is beyond the scope of this paper to offer an in-depth discussion about the different approaches of evaluative, hedonic and eudaemonic well-being. Evaluative well-being refers to a reflective and comprehensive assessment of one's life rather than a description of an emotional state; the hedonic dimension of well-being refers to affective states and emotional experiences and concerns people's current feelings of negative emotions and enjoyment; eudaemonic well-being refers to persons' perceptions of meaning and purpose in their lives and is related to the Aristotelian notion of happiness (Clark et al. 2018; Graham and Nikolova 2015; Kahneman and Krueger 2006; Stone and Mackie 2013). However, as Castellacci and Tveito (2018) argue, there is no contrast between the above concepts both from a theoretical and empirical point of view. Nevertheless, we will empirically focus on the evaluative part of the concept, which is measured through survey questions based on the Cantril ladder of life question (Cantril 1965) and its variations. As Clark et al. (2018) put it, this approach is comprehensive, as it refers to the whole of an individual's life; it involves no aggregation process by researchers, and it aims at capturing individuals' assessments of their lives on the basis of what they consider to be important to themselves.

Both macro- and micro-level papers have attempted to shed light on the role of different determinants of SWB (the empirical literature concerning the relationship between technological innovations and SWB is commented upon in Section 2.2).[1] In the first case, the main research idea is to understand whether the rise in GDP may have any effect on the well-being of a country. The discovery of the Easterlin paradox,

[1] While the use of happiness questions is in general accepted for studying the dynamics and determinants of happiness, it must be noted that responses to such questions can be affected by several biases. Besides biases that are commonly recognised as affecting data from survey questions, such as socially desirable responses and acquiescence, subjects' evaluation of happiness can be affected by other factors, such as recent events (e.g. Schwarz 1987) and weather conditions (e.g. Feddersen et al. 2016). Moreover, as better discussed below, variability in self-reported life satisfaction has raised doubts about the possibility of making comparisons across countries (e.g. Angelini et al. 2014; Brulé and Veenhoven 2017; Van Praag 1971).

which shows a non-linear relationship between income and happiness, is indeed one of the most fruitful strands of literature (Easterlin 1974). Further macro-determinant variables taken into consideration are the level of national income inequality (e.g. Rözer and Kraaykamp 2013), the level of inflation (e.g. Di Tella et al. 2001; Frey and Stutzer 2002) or of unemployment (e.g. Clark and Oswald 1994; Di Tella et al. 2001; Frey and Stutzer 2002), social capital (e.g. Bjørnskov 2006; Bjørnskov et al. 2008; Leung et al. 2011; Rodríguez-Pose and von Berlepsch 2014; Sarracino 2013; Sulemana 2015), economic and political freedom (e.g. Frey and Stutzer 2002; Veenhoven 2000) democratic participation (e.g. Frey and Stutzer 2000, 2002) or government size (e.g. Bjørnskov et al. 2007).[2] Similarly, a rising strand of literature is that related to the impact of the recent economic crisis (e.g. Gonza and Burger 2017) or sudden economic shock, such as the one experienced by transition countries (e.g. Djankov et al. 2016). Inside this macro-level literature, the possibility that technological variables may affect SWB has rarely been taken into consideration (see Section 2.2).[3]

Regarding the micro-economic side of SWB, a quite extensive literature has been produced over the last two decades, recently going beyond some well-known determinants, such as socio-demographic variables like age (e.g. Frijters and Beatton 2012; Laaksonen 2018), health status (e.g. Gerdtham and Johannesson 2001; Graham 2008), education (Gerdtham and Johannesson 2001), civil status (Gerdtham and Johannesson 2001; Stutzer and Frey 2006) and having children (e.g. Cetre et al. 2016). Recent literature has tried to take into account some 'context' variables, such as living in the countryside (e.g. Sørensen 2014) or in a less polluted place (e.g. Ferreira et al. 2013), the role of climate change (e.g. Maddison and Rehdanz 2011) and the need to commute to go to work (e.g. Lorenz 2018).

Inside this quite extensive literature, the role of heterogeneities across countries or groups of countries has been considered an important point to take into account. For example, Sarracino (2013) showed that high-income and low-income countries are quite different in their micro-level happiness determinants; in the same way, the heterogeneity of countries from a geographical and cultural point of view has been taken into consideration, such as in the case of transition countries (e.g. Bartolini et al. 2017) or East Asian countries (e.g. Lim et al. 2020), finding that the happiness paradox is not universally verified and may not be at play for such groups of countries. Various motivations can justify these results, and they can also be ascribed to the role of societal values. Moreover, as Falk et al. (2018) described, several differences may exist, both within and between countries, concerning economic as well as time preferences.

Besides a benchmark full estimate (reported in Appendix 1, Table 8) that partially confirms our HPs, the evidence summarized above induced us to investigate our research questions referring to different regions, also considering that a Chow test run on our data revealed that the coefficients of our independent variables of main interest varied across the different regions considered (see Section 3).

[2] Bjørnskov et al. (2008) also included in their analysis several political and cultural determinants, finding that only a few variables can be considered as affecting countries in the same way, whereas others depend on a specific national context.

[3] For a recent survey on determinants of happiness, see Nikolova and Graham (2020).

2.2 The use of technological goods and SWB

Technological goods are present in our daily life in a very pervasive way, and we currently consume in large quantities the material outcomes of firms' innovation activities. The literature has started to investigate the impact of innovations on SWB from this perspective, that is through the use of technological devices. As Engelbrecht (2014, 2018) illustrates in his framework, this 'consumption' perspective is one of the channels through which innovation can impact on SWB. The literature has mainly concentrated on a micro-level perspective, as our approach does. A limited macro-level literature has analysed the topic as well, though using a different approach, as it is not possible in this case to account for the personal use of technological devices as well as for the role of personal attitudes towards science and technology. Three papers are worth mentioning. The first is that by Ganju et al. (2016), who investigate the channels through which ICT can affect SWB. By using Gallup Word Poll data from 2006 to 2014, they find that ICT can exert positive effects on SWB through several mechanisms: fostering lower social inequality, improving health due to greater awareness of health issues, enhancing the level of education through the possibility of taking on-line courses and improving the level of commercial exchanges through e-commerce. However, these beneficial effects of ICT are not the same across countries. For example, an increase in the use of mobile phones in high-income countries does not automatically lead to higher SWB. It is important to stress this point, which highlights the role of the heterogeneity of countries with respect to the effects of different types of technologies on life satisfaction.[4] The second study worth mentioning is that by Aldieri et al. (2021), who, following the conceptual elaborations put forward by Engelbrecht (2014, 2018) and using a time-series approach on a group of European countries, find negative effects of innovations, measured in terms of patents, on SWB mediated by the level of inequality. They mention as a further channel the use of ICT, but they do not test it in an empirical way. Finally, Maiti and Awasthi (2020), by referring to the theoretical framework developed by Castellacci and Tveito (2018), use cross-country data to investigate the impact of ICT exposure on an objective measure of well-being, finding an overall positive effect that is nevertheless lower for lower-income countries.

Most of the literature has tried to shed light from a micro-level perspective on the role of technological behaviour on SWB. Some early papers referred only to older and conventional technological devices, such as the TV. For example, Bruni and Stanca (2006) find that television viewing has a negative effect on SWB, especially for those who are heavy TV users, as this behaviour contributes to generating higher material aspirations and favours both adaptation and positional effects. In a further article, Bruni and Stanca (2008) find that the number of hours spent watching TV may act as a barrier to the consumption of relational goods, thus negatively affecting SWB. Later, attention was given to more recent technological devices, such as the smartphone and internet. In this respect, Kavestsos and Koutroumpis (2011) find

[4] In this paper, the use of ICT is proxied by three variables that consider the number of fixed telephone lines, internet users and mobile phones.

a positive effect on SWB for internet access using the Eurobarometer Survey Series for the period 2005–2008 for 29 countries.[5] The same positive impact with respect to the internet use is shown by Graham and Nikolova (2013) for the period 2009–2011 for quite a large sample of countries. An important discovery of their study is that the positive effect is different when considering different groups of people, that is for those who are already heavy-technology users the effect is lower. Dividing the sample into different income groups of countries, they find that access to technology, despite the technological device considered, is less important to enhance SWB for the poorer than richer nations. In the same way, Pénard et al. (2013) discover for the case of Luxembourg that Internet use has a greater positive influence on SWB, specifically for those of a younger age and those who receive lower satisfaction from income. Rotondi et al. (2017) find that while generating a direct positive effect on SWB, the use of the smartphone also reduces the quality of face-to-face relations and, as a consequence, their positive effect on well-being. Nie et al. (2017), who analyse the case of China by going in depth into the reasons for which people use the internet and disentangling specific online activities, provide evidence of a negative effect of the intensity of internet use on SWB.[6] Some contributions highlight a mixed effect. Lohmann (2015) shows a positive effect of internet use on SWB while emphasising that through the internet people may change the way they value their lives, having more chances to compare themselves with others and in this way raising their material aspirations. This lowers the effect of income on SWB, especially in contexts endowed with an advanced internet infrastructure. He analyses the role of broadband penetration but considering only the use of PCs and limiting the analysis to a small sample of 29 European countries over the period 2004–2009.

A theoretical approach dealing with the effects that the internet may have on SWB is employed by Castellacci and Tveito (2018), who, besides surveying the literature, propose a new framework for the mechanisms through which interpreting how the internet may affect our lives: they are relative to the change in the way we use our time, the possibility of being part of other activities, the higher possibility of having access to more information and the availability of further communication tools. The authors highlight that each channel can be quite different from one another and equally conducive to possible positive as well as negative effects.

As evidenced from the literature produced on this topic, two contradictory effects emerge from the analysis. On the one hand, the internet can facilitate several dimensions of everyday life as well as personal relationships. This may occur because people can be better informed and educated, can activate

[5] They also consider the role of TV finding positive effects as well.

[6] A further strand of literature examining the effect of the internet is the one dealing more specifically with the use of social networks (SNS). Only a few studies examine this aspect, among which is the study on Italy by Sabatini and Sarracino (2017), who find a negative effect of the use of SNS on life satisfaction, mediated by trust. A recent survey of this argument is provided by Verduyn et al. (2017), who distinguish between passive and active use of SNS. In the first case, they detect a negative effect on life satisfaction because of the presence of a 'comparison' effect, while a positive effect appears when an active use of SNS is done. Arampatzi et al. (2018) find no relationship between the time spent on SNS and happiness.

multiple contacts with friends and family and therefore raise their social capital. On the other hand, spending too much time managing a 'virtual life' can become dangerous because of the time taken away to face-to face interactions, thus underlining the feelings of loneliness that can occur, in addition to having more opportunities to compare our lives with those of our peers.

In this brief literature review so far, what is lacking is an examination of the role of technological infrastructures in the direct effect of the use of technological devices on SWB. Indeed, if we want to adopt a comparative perspective, we need to take into consideration that in different countries the possibility of accessing ICT resources may be hampered or favoured by the respective presence of a weak or strong ICT infrastructure. This mediating effect has never been considered before. For this reason, in our study, we focus not only on the direct effect on SWB possibly generated by internet use to collect information but also on whether it can be mediated by the efficiency of the ICT infrastructure.

2.3 Scientific and technological beliefs and SWB

Only a very limited literature has studied the role that technological and scientific beliefs play in impacting the degree of life satisfaction, while no studies have analysed the role of the quality of the technological infrastructure in mediating this effect. As the few results suggest at the individual level, the role of technological and scientific attitudes can positively affect SWB through a sort of compensatory control function. People may feel that they wish to dominate the real world and are allowed to adopt an optimistic attitude towards the future. Stavrova et al. (2016), through both experimental and survey evidence, recognise that having strong scientific beliefs leads to experiencing a greater sense of control over one's life, therefore increasing SWB. They also find that the role played by the technological environment in which people live may have an impact as well. This means that living in a country characterised by a more deeply rooted 'technological culture' may favour the impact of personal technological belief on SWB. Farias et al. (2013) considered through experimental evidence whether people who do not believe in God can achieve a sense of meaning and purpose in life through scientific beliefs. Similarly, Aghababaei et al. (2016) find that scientific beliefs can be useful mediators in the achievement of a higher SWB because they can alleviate the sense of anxiety related to the fear of death as well as giving a purpose in life. Therefore, this type of literature highlights that scientific and technological beliefs may actually impact on SWB, and they can represent a specific means through which people can attach a meaning to life. A positive effect of technological and scientific attitudes on SWB has also been highlighted by Bhuiyan and Szulga (2017), who perform an empirical test to check the robustness of some of mostly widely used micro-level determinants of SWB. One of their main findings is that, in accordance with older studies on the topic, some determinants are positively related to SWB worldwide such as

health and income and also a measure of technological and scientific attitudes, while other are related to specific economic and social contexts that characterise each group of country.

As a whole, as Kerschner and Ehlers (2016) argue, not enough effort seems to have been put into the examination of people's technological and science beliefs in the economics literature. This has become part of the European Union's investigation through the Eurobarometer polls that started after 2000 (e.g. Eurobarometer 2013) and went on through the years spurred by the so-called 2020 EU strategy, in which the role of innovation is crucial. Among the reasons for the beginning of this investigation was the need to introduce science and technology (S&T) policies that are beneficial for a country's competitiveness and the consequential need for a certain degree of public support (Besley 2013; Muñoz et al. 2012). However, much of the effort has been made to understand what the characteristics of the people who are going to appreciate technology and science[7] are, without considering the impact on SWB.

We therefore complement the empirical literature relative to the impact of technological devices on SWB by introducing the role of optimism about technological and scientific progress and by studying the role of the quality of technological infrastructure and its possible connection with SWB.

3 Theoretical hypotheses

Our first hypothesis is that the use of internet to retrieve information is positively associated with SWB. In fact, the use of Internet as an information source provides people with the opportunity to collect more data in less time and with lower waste of energy in comparison with alternative sources. Moreover, we expect that the positive association between internet use and SWB can be emphasized by the quality of the technological infrastructure. We hypothesise that the more efficient the internet connection, the greater

[7] One of the strands of literature in the social sciences domain that deals with technological and science attitudes is called 'public understanding of science' (PUS): one of the main points discussed is relative to the deficit model that focuses on the supposed relationship between a higher level of scientific and technological knowledge and a more positive attitude towards science (on this, see the meta-analysis by Allum et al. (2008) and the approach from an historical evolution perspective by Bauer (2009)). Further elaborations, for example that of Guenther and Weingart (2018), have pointed out that the role of different groups of people characterised by specific features (such as social class, gender, geographical location) could generate different results with respect to science and technology attitudes. Some limited empirical evidence linking economics with the PUS debate is evidenced in a paper by Sanz-Menéndez and Van Ryzin (2015). The authors find that the economic crisis in Spain has led to an increase in positive attitudes towards science and technology in accordance with the post-industrial model of the PUS debate. It is first evidenced that more positive evaluation of science and technology can be found in those regions characterised by a lower level of development. Moreover, the interest in science as well as the propensity to support S&T policies are higher in regions where unemployment is higher, that is where the economic crisis was more difficult to deal with.

the direct effect of internet use on SWB. In fact, a faster connection allows subjects to retrieve more information in less time. It allows to satisfy needs in terms of collection of information with greater efficiency than in the case of a slower connection. Whether information is needed to organise some activities or to satisfy a curiosity, a faster connection produces more benefits at a lower cost. Therefore, despite the ambiguous effect on SWB of the use of technological goods highlighted in the literature and discussed in Sections 1 and 2, we argue that, with specific respect to the intensity of internet use to retrieve the information analysed in this study, the quality of the technological infrastructure positively mediates the effect on SWB.

Note that we do not maintain that a more efficient technological infrastructure always implies a greater positive effect of any technological behaviours on SWB. We argue that a poor technological infrastructure may prevent the (positive or negative) effect of technology from arising. We neither exclude that with respect to some behaviours, including internet use to get information, the efficiency of the technological infrastructure might be pivotal in determining the positive or negative effect on SWB. For example, if the slowness of the internet connection used as a source of information did not allow the retrieval of the desired information or implied a significant waste of time, the use of technology could be frustrating and might negatively affect SWB. However, this would induce rational subjects to look for other sources of information.

Since technological infrastructures differ in quality both across countries and within groups of countries, we argue that their role in affecting the relations between internet use to obtain information and SWB should be carefully considered.

Hp1A The higher the use of Internet to retrieve information, the higher the level of SWB.
Hp1B The higher the quality of the internet infrastructure, the higher the effect on SWB of the intensity of internet use as a source of information.

Regarding the issue of the effect of technological and scientific beliefs on SWB, we focus on the optimism concerning the usefulness of scientific and technological progress. Our hypothesis is that technological and scientific beliefs are positively associated with SWB. It is rooted in compensatory control theories, which maintain that beliefs may have control functions (Kay et al. 2008; Rothbaum et al. 1982; Stavrova et al. 2016). People benefit from perceiving themselves as being in control of their lives. Having a sense of control is recognised as generating a positive effect on well-being (Stavrova et al. 2016); moreover, empirical evidence has shown that the feelings of freedom of choice and control over the life are associated with happiness and life satisfaction (Creed and Bartrum 2008; Gerstorf et al. 2014; Verme 2009), while lack of control generates anxiety and may have a negative effect on health (Spector 2002). If immediate personal control is lacking, individuals try to use secondary or compensatory sources to restore it (Landau et al. 2015; Stavrova et al. 2016). Among possible compensatory

sources the important role played by beliefs in technological and scientific progress has been highlighted in several works (Rutjens et al. 2010, 2013; Farias et al. 2013; Meijers and Rutjens 2014; Gottlieb et al. 2018).[8] As evidenced, science and technology may represent a mechanism through which people increase their control over their environment, their lives, the future and existential threats, in this way positively affecting SWB (Stavrova et al. 2016). We note that optimism as such is not expected to be necessarily associated with higher SWB. In fact, we may in general assume that some behaviours connected with optimism, such as those related to overconfidence and risk-taking, may also end up having a negative effect on SWB. This seems to be confirmed by the empirical evidence showing that happiness appears to be associated with risk aversion (Goudie et al. 2014; Guven and Hoxha 2015); however, we specifically focus on optimism with respect to technological and scientific progress and argue that its effect on SWB is positive. In our analysis we control also for the effect on SWB of variables that may be negatively affected by optimism via overconfidence and risk-taking, such as income and health. This allows us to consider the relation between SWB and optimism in technological and scientific progress net of some further effects that optimism may have also affecting other determinants of SWB.

Moreover, we expect a greater effect on SWB of technological and scientific beliefs in contexts characterised by a lower quality of internet infrastructure. As evidenced in several works, technological development and information technology increase capabilities and empowerment (Aker and Mbiti 2010; Graham and Nikolova 2013; Castellacci and Tveito 2018). Therefore, we argue that the positive effect on SWB of the optimism regarding scientific and technological progress due to its role as a secondary or compensatory source of control is higher in areas where lower technology development allows poorer control over the environment and existential threats. In fact, the lower the technological development, the higher and more urgent the need for a secondary source of control over one own life.By considering the quality of the internet infrastructure as a proxy for technological development, we expect that subjects living in areas with a lower quality level of such infrastructure may benefit more from their trust in technological and scientific progress than subjects who can exploit more the actual potentiality of technology.

Hp2A The higher the optimism regarding technological and scientific progress, the higher the level of SWB.
Hp2B Technological and scientific beliefs are expected to positively affect SWB to a greater extent in areas characterised by an internet infrastructure of lower quality.

[8] Experimental results have shown that a decrease in an individual's sense of personal control generates an increase in the belief in scientific–technological progress (Rutjens et al. 2010; Stavrova et al. 2016).

Table 1 Distribution of the sample across groups of countries

Region	Freq	Perc
East Asia	16,634	19.28
East Europe	8,571	9.93
Central Asia	10,839	12.56
South America	11,439	13.26
Middle East	10,768	12.48
Europe-Anglo Saxon	10,893	12.63
Africa	17,128	19.85
Total	86,272	100

4 Data set, methods and variable description

4.1 Data set

To analyse our research questions, we opted for a cross-country database to provide more generalisable results and put into evidence possible regional heterogeneities. The sixth wave of the World Value Survey (2010–2014) includes a total of 86,272 observations for about 60 different countries (both developed and developing). This data set collects a large amount of information on several dimensions of human life encompassing those relative to SWB, personal beliefs, as well as some socio-demographic factors (Inglehart et al. 2014). More specifically, we used the sixth wave because it provides information on the use and frequency of some technological devices, and in particular the internet, which are not included in the previous waves. Not all variables were available for all countries.[9] Due to the cross-nature of the data, we cannot exclude the fact that our results may be affected by endogeneity problems because of non-observed heterogeneity and reverse causality, even though our estimates control for region fixed effects and include individual control variables usually considered in the empirical literature on the determinants of SWB. Indeed, with respect to reverse causality, life satisfaction may have a role in favouring internet use to retrieve information or in promoting optimism regarding technological and scientific progress, even though the impact through the mediation of technological infrastructure should not be affected by such problem.

We used the World Bank classification to break the sample down into groups of countries (regions). In Table 6 in the Appendix 1, we provide a list of all countries in each region. The average number of respondents is characterised by a different distribution across regions (see Table 1).

[9] For some questions, people replied "Don't know" or the question is considered "Not applicable" or "No answer" was given: in all these cases, the observation is considered to be missing.

4.2 Methods

The equation we estimate is the following:

$$SWB_{ij} = \alpha + \beta_1 INTERNET_{ij} + \beta_2 TECHNOBELIEF_{ij} + \beta_3 BROADBAND_j + \beta_4 SOCIO - DEMO_{ij} + \beta_5 INTERNET_{ij} * BROADBAND_j + \beta_6 TECHNOBELIEF_{ij} * BROADBAND_j + \varepsilon_{ij} \quad (1)$$

where i refers to individuals and j to countries. ε_{ij} represents the stochastic error term. As clarified below, the dependent variable has an ordinal nature, and estimating the model through an ordinal probit technique would be more appropriate. Nevertheless, as is customary in this type of literature, we run the models using a standard OLS.[10] As Ferrer-i-Carbonell and Frijters (2004) points out, the differences are negligible and results can be easier to interpret. In order to investigate the role of the quality of the technological infrastructure in the impact on SWB of internet use to retrieve information and optimism regarding technological and scientific progress, we consider the role played by the amount of fixed broadband subscriptions per 100 people (variable named *BROADBANDj*). Data concerning this variable are taken from the World Development Indicators (WDI). Fixed broadband subscriptions 'refer to fixed subscriptions to high-speed access to the public Internet (a TCP/IP connection), at downstream speeds equal to or greater than 256 kbit/s'.[11] This variable took the same value within each country.

4.3 Dependent variable

We measure SWB using answers to the following question: *'All things considered, how satisfied are you with your life as a whole these days?'* The answers were given on a scale ranging from 1 (dissatisfied) to 10 (satisfied). In Fig. 1 we show the distribution of the answers for the whole sample. The values are concentrated between 7 and 8, with the highest frequency being 20.6 of ladder 8, which indicates that people felt quite satisfied overall. However, the mean of the variable was 6.84, meaning that the heterogeneity of the countries involved in this sample was quite high. To dig deeper in this overall framework, we present the distribution of the variable, dividing countries into regions. In Fig. 2, we show that the variability among regions was not negligible, with Europe–Anglo-Saxon countries showing ladder 8 with the highest frequency (around 30%).

[10] As a robustness check, we run also ordered probit estimates (see Section 5).

[11] 'This includes cable modem, DSL, fibre-to-the-home/building, other fixed (wired) broadband subscriptions, satellite broadband and terrestrial fixed wireless broadband. This total is measured irrespective of the method of payment. It excludes subscriptions that have access to data communications (including the internet) via mobile cellular networks. It should include fixed WiMAX and any other fixed wireless technologies. It includes both residential subscriptions and subscriptions for organisations.' (WDI)

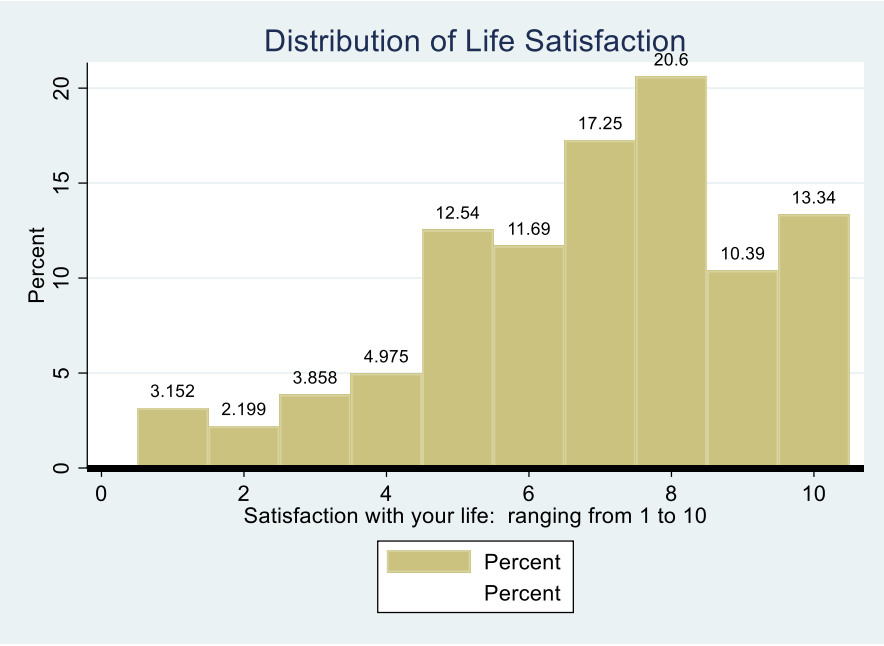

Fig. 1 Life Satisfaction Distribution – full sample. Source: Authors' elaboration

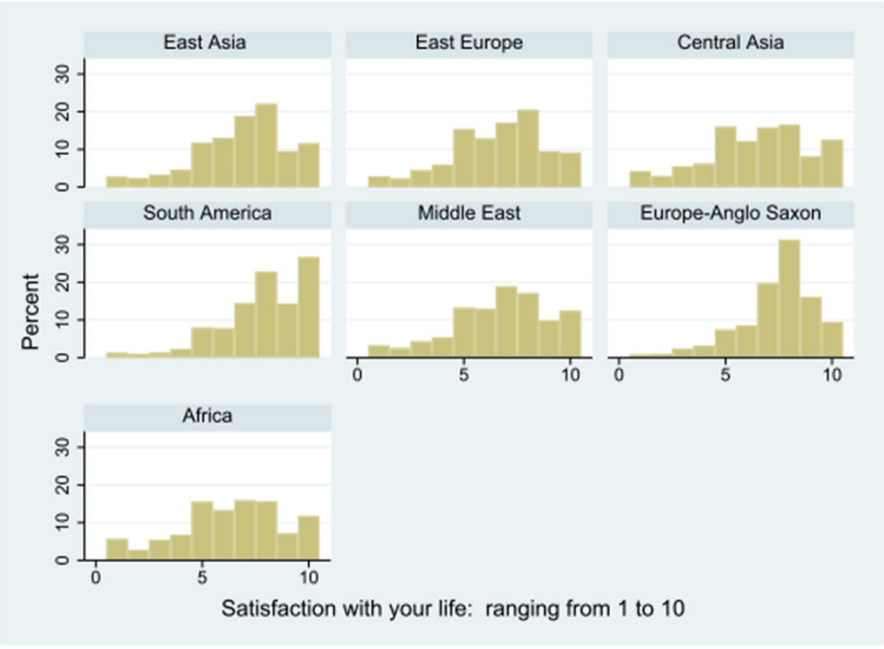

Fig. 2 Life Satisfaction Distribution: Sample Divided by Region. Source: Authors' elaboration

4.4 Independent variables of main interest

The focal independent variables capture technological behaviour in terms of internet use as a source of information ($INTERNET_{ij}$) and beliefs ($TECHNOBELIEF_{ij}$) that refer to two variables concerning technological and scientific beliefs (*Tech_beliefs* and *Science&tech_belief*). The first variable is based on answers to the following statement: '*People learn what is going on in this country and the world from various sources. For each of the following sources, please indicate whether you use it to obtain information daily, weekly, monthly, less than monthly or never*' with respect to '*Information source: Internet'*. The scale of the variable ranges from 1 (daily) to 5 (never). We transformed the variable into a dummy equal to 1 when the original value is equal 1, that is when a person is a heavy user.

Regarding technological and scientific beliefs, as Kerschner and Ehlers (2016) recommend, we use two separate variables based on two different questions to capture the possibly different levels of optimism about technological and scientific progress. The first variable (*Tech_beliefs)* is focalized on technology and refers to the answer relative to the approval rating of the following sentence: *'I'm going to read out a list of various changes in our way of life that might take place in the near future. Please tell me for each one, if it were to happen, whether you think it would be a good thing, a bad thing, or don't you mind?*' concerning '*More emphasis on the development of technology'*. The scale of the variable ranges from 1 (bad thing) to 3 (good thing). For ease of interpretation the variable is used in the regressions as a dummy: it is equal to 1 when the value of the original variable is equal to 3, thus depicting the highest degree of positive beliefs towards technology (*Tech_beliefs)*. The second variable we use (*Science&tech_belief*) also includes a specific reference to science; it is based on responses to the following statement: '*Because of science and technology, there will be more opportunities for the next generation*'. The scale of the variable ranges from 1, completely disagree, to 10, completely agree (will help). The variable is a dummy equal to 1 when the value is higher than 5, that is when people show a higher degree of optimism about science and technology. These two variables have in common the expression of a more or less optimistic view of science and/or technology for the future. However, the first one (*Tech_beliefs*) is narrowly focused on technological progress, while the second one (*Science&tech_belief*) explicitly refers to the effect of both technology and science. It could be that asking people about both science and technology had a reinforcing effect on their technological beliefs, thus generating possible differences in the relationship between these two variables and SWB. However, the two variables also differ in both the way they are formulated, the second one referring to the next generation, and in the scale of available replies. Consequently, it may be that possible changes in the results are due to a typical framework effect in responding due to these differences.[12]

[12] As a robustness check we also run the regressions presented in Section 5 by considering the variable capturing the intensity of the use of Internet and the variables concerning the technological and scientific beliefs according to their original scale, that is: a scale from 1 (daily) to 5 (never) for Internet; a scale from 1(bad thing) to 3 (good thing) for *Tech_beliefs*; a categorical variable ranging from 1 to 10 for *Science&tech_beliefs*. The interpretation of results is virtually unchanged with respect to that concerning the results obtained using the dummy variables. The main change concerns the statistically significance of the negative coefficient of the interaction between the *Internet* variable and the *Broadband* variable when the MENA region is considered. Note that a similar result characterises the South American region (see footnote 14 for the relative comment). Estimates are available upon request.

Table 2 provides information about internet use and declared beliefs across and within regions. When considering data within each region—the last line of each sub-table—we observed that the region characterised by the highest use of the internet is the Europe–Anglo-Saxon one, while the region with less intensive use is Africa. These regions are also those characterised by a higher and lower average level of reported SWB, respectively (Europe-Anglo-Saxon mean = 7.40, stdv = 1.80; Africa mean = 6.31, stdv = 2.45). More generally, Africa, Central Asia, South America and East Europe were the groups of countries with the lowest percentages of 1 in the *Internet* variables. They also reported percentages of subjects with positive technological beliefs (variable *Tech_beliefs* equal to 1) higher than 70%. Conversely, in the Europe–Anglo-Saxon area, only 55% of people show positive technological beliefs. The percentage of subjects who believe that, because of science and technology there would be more opportunities for the next generation (*Science&tech_beliefs*) is quite high in Africa, Central Asia, South America and East Europe; the lowest value for this belief was seen in South America. Finally, in all regions, the percentage of positive scientific and technological beliefs (variable *Science&tech_beliefs* equal to 1) is higher than the percentage of positive technological beliefs (variable *Tech_beliefs* equal to 1), with differences ranging between 26.4% for Europe–Anglo-Saxon and 7.38% for South America.

4.5 Control variables

In accordance with the relevant literature, we account for most of the individual level determinants of life satisfaction by considering a vector of the common socio-demographic variables ($SOCIO\text{-}DEMO_{ij}$) that are usually included in micro-level studies (e.g. Dolan et al. 2008). They are represented by age (*Age*) and age squared (*Age sq*) to account for the likely U-shape relationship with SWB; marital status, namely being single, is negatively associated with life satisfaction regarding sharing life with a person. We measure this aspect by including a dummy (*Single*) which is equal to 1 if the person is single/never married and 0 for all the other categories. Health status (*Health*) is measured through a categorical variable ranging from 1 (very poor) to 4 (very good), representing answers to the following question: '*All in all, how would you describe your state of health these days?'* We expect a positive effect for this variable, as most of the literature has found previously (e.g. Borghesi and Vercelli 2012; Graham 2008). A further dummy variable equal to 1 is included for being female (*Gender*) as women are expected to get a higher degree of satisfaction from life than men. Education, which may have an uncertain effect on SWB, is captured by a variable indicating the highest level of education (*High_edu*) that respondents have achieved (e.g. Chen 2012). This variable ranges from 1 (lowest level, that is '*Inadequately completed elementary education*') to 8 (highest level, that is '*University-level education completed with a degree*'). One of the key variables in these types of studies is household income (*Income*). Following the literature (e.g. Bjørnskov et al. 2008), it is built as a categorical variable ranging from 1

Table 2 The use of internet and declared beliefs across and within regions

	East Asia	East Europe	Central Asia	South America	MENA	Europe-Anglo-Saxon	Africa	Total
Internet								
n. of 0	10,473	5,166	8,395	8,224	7,038	4,092	12,696	56,084
% in the total sample	18.67	9.21	14.97	14.66	12.55	7.3	22.64	100
n. of 1	4,799	3,273	2,412	3,120	3,488	5,428	3,111	25,631
% in the total sample	18.72	12.77	9.41	12.17	13.61	21.18	12.14	100
Total	15,272	8,439	10,807	11,344	10,526	9,520	15,807	81,715
	18.69	10.33	13.23	13.88	12.88	11.65	19.34	100
% of 1 within each region	31.42	38.78	22.32	27.50	33.14	57.02	19.68	
Tech_beliefs								
n. of 0	6,058	2,448	3,066	3,127	2,815	4,671	4,544	26,729
% in the total sample	22.66	9.16	11.47	11.7	10.53	17.48	17	100
n. of 1	10,250	5,753	7,647	7,844	7,648	5,710	11,784	56,636
% in the total sample	18.1	10.16	13.5	13.85	13.5	10.08	20.81	100
Total	16,308	8,201	10,713	10,971	10,463	10,381	16,328	83,365
	19.56	9.84	12.85	13.16	12.55	12.45	19.59	100
% of 1 within each region	62.85	70.15	71.38	71.50	73.10	55.00	72.17	
Science&tech_belief								
n. of 0	2,982	1,173	1,231	2,335	1,913	1,983	2,332	13,949
% in the total sample	21.38	8.41	8.83	16.74	13.71	14.22	16.72	100
n. of 1	12,626	7,064	9,510	8,720	8,545	8,677	14,120	69,262
% in the total sample	18.23	10.2	13.73	12.59	12.34	12.53	20.39	100
Total	15,608	8,237	10,741	11,055	10,458	10,660	16,452	83,211
	18.76	9.9	12.91	13.29	12.57	12.81	19.77	100
% of 1 whitin each region	80.89	85.76	88.54	78.88	81.71	81.40	85.83	

to 10, in which each respondent should subjectively position their household's income on the scale.[13] We also control for the respondent's employment status (*D_employment*) through a dummy variable indicating whether the respondent is employed full-time, and from all other categories, the most important was being self-employed or unemployed. We report robust standard errors in all regressions.

In Table 7 in the Appendix 1, we show some descriptive statistics of variables for the overall sample.

4.6 The quality of technological infrastructures

Table 3 summarises the average, minimum and maximum values of broadband penetration (*Broadband*) with respect to each region and the number of observations included in each subsample. The average value of the variable at regional level reveals that Africa, Central Asia and Middle East are characterised by the lowest broadband penetration rate. The highest penetration rate is in the Europe–Anglo-Saxon region. The diffusion of positive beliefs about technology and science (Table 2) seems to be higher in the regions characterised by lower rates of broadband penetration, with Africa and Middle East showing the highest percentages of 1 for the *Tech_beliefs* variable and Africa and Central Asia showing the highest percentages of 1 for the *Science&tech_beliefs* variable. Moreover, the Europe–Anglo-Saxon region presents the highest broadband penetration rate and the lowest percentage of 1 for the *Tech_beliefs* variable. Regarding internet use (Table 2), we observe that regions with high broadband penetration rates seem to reveal high percentages of subjects who use internet as a source of information, even though there is not a strict correspondence between the two variables, with the Middle East and North Africa representing the most significant exception, with quite a high percentage of people using the internet to collect information and a low broadband penetration rate.

5 Results

In Tables 4 and 5, we report the results of our OLS regressions obtained by dividing the sample according to the macro-geographical regions. Table 4 includes *Tech_beliefs,* and Table 5 shows *Science&tech_beliefs*. Results obtained with the ordered probit estimator remain virtually unchanged (see Tables 9 and 10 in the Appendix 1). We also run a benchmark regression (Table 8 in the Appendix 1) with the full sample (including macro-region fixed effects). These results confirm Hp2A and Hp2B pointing to the fact that optimism concerning the usefulness of scientific and technological progress is positively associated with SWB and that it affects SWB to a greater extent in areas characterised by an internet infrastructure of lower

[13] The question's wording is as follows: '*On this card is an income scale on which 1 indicates the lowest income group and 10 the highest income group in your country. We would like to know in what group your household is. Please specify the appropriate number, counting all wages, salaries, pensions and other incomes that come in*.".

Table 3 Broadband penetration rate at macro-regional level

	Obs	Mean	Stdv	Min	Max
East Asia	15,396	16.073	11.855	0.810	34.704
East Europe	8,571	19.258	5.481	12.272	26.282
Central Asia	10,839	8.490	7.107	0.510	22.284
South America	11,439	10.548	3.002	4.890	14.814
Middle East and North Africa (MENA)	7,568	8.841	6.308	1.300	21.524
Europe-Anglo-Saxon	10,893	30.937	5.482	23.719	39.626
Africa	15,369	1.989	1.451	0.052	4.747

quality. In the same way, the role of internet, even though not significant, is positive as expected both in its direct and interacted effect on SWB according to Hp1A and Hp1B. Following these benchmark results, we nevertheless want to go deeper into the analysis in order to account for macro-regional heterogeneities. In the tables, we interacted the variable measuring the broadband penetration rate (*Broadband*) with the independent variables of main interest, i.e. *Internet* and *Tech_beliefs* in Table 4 and *Internet* and *Science&tech_beliefs* in Table 5. The tables also show the coefficients of control variables included in the estimates. We found that the main stylised facts relative to SWB determinants were generally confirmed. Indeed, age and age squared have the expected non-linear trend. In addition, being female and married is positively related to SWB as expected. The variable measuring income is positively and highly significant confirming that a higher level of income has a positive impact on life satisfaction. Moreover, as expected, being healthy has a positive impact as well. We acknowledge, that these results are consistent across all regions, while the same is not true for being employed full-time, which is mainly not significant or weakly positive.

When focusing on the effect of the interaction between internet use and the technological infrastructure, we see that, as our Hp1B predicts, in both tables the effect is positive and significant across all regions, except South America.[14] This evidence shows that the quality of technological infrastructure tends to favour a greater positive effect on SWB of internet use to retrieve information.

When considering internet use, when not interacting with other variables, in both the tables we see that in most regions it is positive and significant (weakly most of the time) as expected by Hp1A. Two exceptions are East Asian and Europe–Anglo-Saxon countries, where the coefficient is negative and significant. To better interpret the negative coefficient characterising internet use in these areas, we include in the previous regressions a dummy variable instead of the continuous one for capturing

[14] A clear interpretation for this result concerning the South American region cannot be derived from our analysis. It may be due to an effect of the diffusion of technological infrastructure on one or more variables that negatively affect SWB. However, this effect does not emerge with respect to the other groups of countries. It may represent an aspect to be investigated in future research on the topic.

the level of broadband penetration rate. In each region, the dummy takes the value of 1 for the subsamples of subjects who live in areas characterized by a broadband penetration rate higher than the average of the region. This allows us to directly analyse the effect of internet use on SWB of subjects living in countries characterised by higher or lower levels of broadband penetration. By considering this analysis with respect to the Europe–Anglo-Saxon region, the *Internet* coefficient indicates that using the internet intensively tends to decrease the SWB of subjects living in countries with a lower level of broadband penetration (the coefficient is equal to -0.0945482 (p = 0.092) and to -0.0895513 (p = 0.107) when *Tech_beliefs* and *Science&tech_beliefs* are considered, respectively). Conversely, we find that in the same region, intensive internet use is positively associated with the SWB of subjects living in countries characterised by higher-quality technological infrastructures.[15] When the East Asian countries are considered, the negative effect of the intensive use of internet on SWB is confirmed with respect to subjects living in countries with lower-quality technological infrastructures, but it disappears when considering subjects living in countries characterised by a higher level of broadband penetration.[16]

This evidence is congruous with the aforementioned results from the literature thus far, according to which, from a general point of view, internet use is positively associated with a rise in life satisfaction, though with distinctions among different groups of people. We argue that where the technological knowledge is quite diffused and people make use of technological devices to a greater extent in everyday life, including for work purposes (such as for the Europe–Anglo-Saxon region in particular), a poor-quality technological infrastructure may have such a negative impact that it generates dissatisfaction in people, who, despite the necessity to use the internet, cannot benefit from an efficient technological infrastructure. As a whole, the main result of our analysis seems to reveal a positive relationship between SWB and internet use as a way to be more informed and a mediating role played by the penetration of broadband thus providing support for our Hp1A and Hp1B.

Regarding our second hypothesis about the role of subjects' beliefs about technology (Table 4 concerning *Tech_beliefs*), we first observe a positive effect on SWB across most of the regions as expected by Hp2A. However, in some cases the effect is not significant, namely for East Europe, West and Anglo-Saxon regions and South America. When we consider the interaction between *Tech_beliefs* and *Broadband* we find that the effect is negative and mainly significant in most regions, with the usual exception of South

[15] Analysis of the linear combination of the estimated *Internet* coefficient and the interaction terms between *Internet* and *Tech_beliefs* or *Science&tech_beliefs* shows that subjects living in countries with a higher-quality technological infrastructure seem to benefit from more intensive use of the internet (lincom *Internet* + *Internet***Broadband* = .108071 [p = 0.032]; lincom *Internet* + *Internet** *Broadband* = .1139287 [p = 0.020]).

[16] With respect to this region, the Internet coefficient is equal to -.3150223 (p = 0.000) and to -.3152255 (p = 0.000) when *Tech_beliefs* and *Science&tech_beliefs* are considered, respectively. With respect to the role of internet use in countries with higher-quality technological infrastructures, we find non significant relations (lincom Internet + Internet* Broadband = .0202285 [p = 0.710]; lincom Internet + Internet*Broadband = .0477222 [p = 0.389].

Table 4 The relationship between the use of Internet, technological beliefs and SWB

VARIABLES	East Asia	East Europe	Central Asia	South America	MENA	Europe—Anglo-Saxon	Africa
Age	-0.0235***	-0.0488***	-0.0432***	-0.0277***	-0.0200*	-0.0343***	-0.0189**
	(0.00876)	(0.00834)	(0.00763)	(0.00709)	(0.0115)	(0.00651)	(0.00912)
Age sq	0.000366***	0.000558***	0.000417***	0.000314***	0.000271**	0.000448***	0.000360***
	(9.31e-05)	(8.49e-05)	(7.88e-05)	(7.70e-05)	(0.000133)	(6.53e-05)	(0.000107)
High_edu	0.0506***	-0.0302**	-0.0104	0.00410	0.00714	-0.00884	0.0261**
	(0.0109)	(0.0126)	(0.0121)	(0.0105)	(0.0124)	(0.00948)	(0.0109)
Gender	0.221***	0.136***	0.203***	0.0541	0.175***	0.123***	0.139***
	(0.0395)	(0.0446)	(0.0408)	(0.0418)	(0.0510)	(0.0362)	(0.0407)
Single	-0.0677	-0.335***	-0.153**	-0.282***	-0.378***	-0.448***	0.0365
	(0.0605)	(0.0666)	(0.0648)	(0.0516)	(0.0680)	(0.0515)	(0.0525)
D_employment	0.0705*	0.0659	0.0584	-0.103**	0.121**	-0.0158	0.0632
	(0.0422)	(0.0498)	(0.0451)	(0.0455)	(0.0555)	(0.0411)	(0.0480)
Health	0.518***	0.829***	0.784***	0.582***	0.571***	0.899***	0.706***
	(0.0271)	(0.0319)	(0.0291)	(0.0297)	(0.0358)	(0.0264)	(0.0273)
Income	0.147***	0.289***	0.377***	0.0353***	0.217***	0.148***	0.313***
	(0.00992)	(0.0139)	(0.0120)	(0.0104)	(0.0147)	(0.00983)	(0.0113)
Tech_beliefs	0.498***	0.290	0.737***	0.0318	0.462***	-0.192	0.151**
	(0.0776)	(0.188)	(0.0727)	(0.180)	(0.101)	(0.224)	(0.0708)
Internet	-0.419***	0.303*	-0.130	0.482***	0.169*	-0.399*	0.0962
	(0.0955)	(0.166)	(0.0828)	(0.167)	(0.0964)	(0.228)	(0.0802)
Broadband	0.00336	0.0128	-0.00749	-0.00122	0.0196***	0.0106*	-0.0214
	(0.00335)	(0.00837)	(0.00548)	(0.0154)	(0.00621)	(0.00639)	(0.0261)
Tech_beliefs* Broadband	-0.0170***	-0.00353	-0.0413***	0.0264	-0.0186**	0.00799	-0.0910***
	(0.00356)	(0.00892)	(0.00600)	(0.0170)	(0.00819)	(0.00677)	(0.0297)
Internet* Broadband	0.0147***	-0.00579	0.0185***	-0.0439***	-0.00110	0.0128*	0.0445
	(0.00401)	(0.00799)	(0.00614)	(0.0158)	(0.00874)	(0.00690)	(0.0315)

Table 4 (continued)

VARIABLES	East Asia	East Europe	Central Asia	South America	MENA	Europe—Anglo-Saxon	Africa
Constant	4.384***	3.667***	3.290***	6.385***	3.851***	4.200***	2.506***
	(0.233)	(0.299)	(0.224)	(0.242)	(0.288)	(0.288)	(0.219)
Observations	11,859	7,744	10,486	9,451	6,521	8,115	12,015
R-squared	0.078	0.215	0.282	0.062	0.116	0.224	0.167

Robust standard errors in parentheses

*** $p<0.01$, ** $p<0.05$, * $p<0.1$

Table 5 The relationship between the use of Internet, technological and scientific beliefs and SWB

VARIABLES	East Asia	East Europe	Central Asia	South America	MENA	Europe—Anglo-Saxon	Africa
Age	-0.0250***	-0.0471***	-0.0433***	-0.0292***	-0.0227**	-0.0342***	-0.0230**
	(0.00885)	(0.00827)	(0.00766)	(0.00696)	(0.0114)	(0.00643)	(0.00907)
Age sq	0.000392***	0.000533***	0.000422***	0.000330***	0.000298**	0.000443***	0.000408***
	(9.43e-05)	(8.42e-05)	(7.91e-05)	(7.55e-05)	(0.000133)	(6.43e-05)	(0.000105)
High_edu	0.0552***	-0.0351***	-0.0166	0.00728	0.00880	-0.0167*	0.0274**
	(0.0109)	(0.0125)	(0.0121)	(0.0105)	(0.0122)	(0.00931)	(0.0109)
Gender	0.218***	0.133***	0.192***	0.0611	0.158***	0.119***	0.156***
	(0.0397)	(0.0441)	(0.0409)	(0.0417)	(0.0507)	(0.0352)	(0.0406)
Single	-0.0526	-0.366***	-0.155**	-0.279***	-0.395***	-0.442***	0.0506
	(0.0607)	(0.0652)	(0.0645)	(0.0515)	(0.0668)	(0.0505)	(0.0525)
D_employment	0.0367	0.0538	0.0589	-0.108**	0.106*	-0.0189	0.0840*
	(0.0426)	(0.0493)	(0.0451)	(0.0454)	(0.0549)	(0.0404)	(0.0478)
Health	0.505***	0.820***	0.785***	0.584***	0.578***	0.881***	0.692***
	(0.0276)	(0.0316)	(0.0292)	(0.0295)	(0.0355)	(0.0262)	(0.0273)
Income	0.135***	0.290***	0.379***	0.0323***	0.209***	0.143***	0.305***
	(0.0100)	(0.0138)	(0.0120)	(0.0104)	(0.0146)	(0.00969)	(0.0113)
Science&tech_beliefs	1.065***	1.080***	0.330***	0.396**	0.612***	0.568*	0.571***
	(0.0986)	(0.256)	(0.104)	(0.184)	(0.118)	(0.313)	(0.105)
Internet	-0.422***	0.250	-0.148*	0.470***	0.195**	-0.386*	0.0977
	(0.0947)	(0.163)	(0.0827)	(0.166)	(0.0939)	(0.222)	(0.0798)
Broadband	0.0144***	0.0424***	-0.0324***	0.0347**	0.0110	0.0172*	-0.0502
	(0.00444)	(0.0126)	(0.00816)	(0.0166)	(0.00870)	(0.00961)	(0.0378)
Science&tech_beliefs *Broadband	-0.0300***	-0.0434***	-0.00643	-0.0264	-0.00423	-0.00755	-0.0306
	(0.00457)	(0.0128)	(0.00844)	(0.0180)	(0.00954)	(0.00966)	(0.0396)
Internet*Broadband	0.0159***	-0.00276	0.0196***	-0.0432***	-0.00394	0.0126*	0.0150
	(0.00399)	(0.00788)	(0.00612)	(0.0157)	(0.00854)	(0.00670)	(0.0315)

Table 5 (continued)

VARIABLES	East Asia	East Europe	Central Asia	South America	MENA	Europe—Anglo-Saxon	Africa
Constant	3.962***	3.088***	3.572***	6.160***	3.768***	3.897***	2.256***
	(0.239)	(0.336)	(0.235)	(0.244)	(0.287)	(0.367)	(0.230)
Observations	11,562	7,778	10,518	9,513	6,552	8,281	12,171
R-squared	0.088	0.215	0.274	0.058	0.124	0.225	0.167

Robust standard errors in parentheses

*** $p<0.01$, ** $p<0.05$, * $p<0.1$

America. This means that the impact of the variable capturing beliefs tends to be higher in areas characterised by a lower rate of broadband penetration. This is in line with our Hp2B, according to which the positive beliefs about the importance of more emphasis on future technological improvements can be less relevant where technology is more widespread and commonly used. The interaction effect is not significant in those areas in which technological beliefs are also not significant when they are not interacted. This seems to suggest that the quality of technological infrastructure can mediate the relationship between technological beliefs and SWB but that it does not have a crucial role in activating it.

The analysis of Table 5, which includes *Science&tech_beliefs* as a proxy for technological and scientific beliefs, seems to confirm the general results about the relationship between beliefs and SWB, which appear to be robust with respect to the measurement of beliefs using different questions concerning technology and science. However, while positive beliefs tend to be correlated with SWB for all the regions considered in the analysis, the mediating role of the quality of the technological infrastructure appears to be less relevant, with the interaction term between *Science&tech_beliefs* and *Broadband* remaining significant only for East Asian and East European countries.[17]

6 Conclusions

In this study, we aimed at providing a more complete picture of the technological side of SWB determinants. Starting from the conceptual framework originally elaborated by Engelbrecht (2014, 2018), we adopted a complementary microeconomic point of view that was mediated by a macroeconomic perspective. In particular, we took a step forward in clarifying the role of technological infrastructure in the impact on SWB of technological behaviour and beliefs concerning technological and scientific progress. This paper can be positioned at the intersection of different strands of literature that have thus far followed quite independent paths; namely, they are represented by the literature on SWB, physiological literature about technological beliefs and the economics of innovation literature.

In the previous micro-level literature, the mediating role of ICT infrastructure has not been properly taken into consideration. In doing so, we employed the sixth wave of the WVS for the years 2010–2014, which covered a large sample of both developed and developing countries. We therefore offer generalisable

[17] Note also that when we included in the estimates *Science&tech_beliefs* instead of *Tech_beliefs*, the *Internet* coefficient became statistically significant, with a negative value also for South America. As already mentioned in footnote 16, this result, along with the negative value for the interaction term between internet use and quality of technological infrastructure, is difficult to explain within our framework and opens the avenue for research focusing on the peculiarities of this region.

results, even though we have not always found common patterns of behaviour across macro regions.

Regarding technological behaviour, we have focused on the role of internet use as a source of information and analysed whether its relationship with SWB is mediated by the quality of internet infrastructure, captured by the broadband penetration rate. We have shown that the broadband penetration rate positively affects the relationship between internet use and SWB. Moreover, we have shown that in two regions the quality of the technological infrastructure was pivotal in determining the positive or negative effect of internet use on SWB. In fact, in the East Asia region and the Europe–Anglo-Saxon region, internet use was negatively related to the SWB of people living in countries with a lower broadband penetration rate. However, in the same regions, the relationship between internet use and SWB became positive when we considered people living in countries with a higher-quality technological infrastructure; this was particularly significant for the Europe–Anglo-Saxon region. The previous result highlights a specific consequence of policy interventions aimed at improving the quality of internet infrastructure, which deserves to be taken into account. Improvement in the infrastructure quality enhances the direct positive effect on SWB of internet use as a source of information.

With respect to the technological beliefs, we considered two proxies for optimism regarding technological and scientific progress, one focusing exclusively on technology and the second one considering both technology and science. Also, with respect to beliefs, we observed a positive effect on SWB, which tended to be greater when the level of broadband penetration was lower. Again, this was an expected result in accordance with our initial hypotheses.

Even though we cannot exclude that within the contexts characterised by different efficiencies of technological infrastructures SWB may play a role in both internet use and optimism about technological and scientific progress, we are pretty confident that our main results, concerning the role of technological infrastructure in mediating the effect of internet use and beliefs on SWB, are not invalidated by possible endogeneity problems. However, we are aware that we have furnished results that can be interpreted in terms of correlations rather than causation. Future research, using panel data, may clarify whether our results change in intensity when the illustrated causality issue is taken into account.

Avenues for further research can be found also in other directions. First, a more dynamic analysis would be useful to understand not only how internet use and technological and scientific beliefs change over time but also how the possible changes are reflected in higher or lower levels of life satisfaction. Second, we focus on internet use as a source of information. Further analysis could investigate if the quality of technological infrastructure plays a role in mediating the effect of other technological behaviours on SWB.

Appendix 1

Table 6 Full list of countries divided by macro-region

East Asia		East Europe		Central Asia		South America		MENA		Europe-Anglo-Saxon		Africa	
China	2,300	Cyprus	1,000	Azerbaijan	1,002	Argentina	1,030	Bahrain	1,200	Australia	1,477	Algeria	1,200
Taiwan	1,238	Estonia	1,533	Armenia	1,100	Brazil	1,486	Palestine	1,000	Germany	2,046	Ghana	1,552
Hong Kong	1,000	Poland	966	Belarus	1,535	Chile	1,000	Iraq	1,200	Netherlands	1,902	Libya	2,131
India	1,581	Romania	1,503	Georgia	1,202	Colombia	1,512	Jordan	1,200	New Zealand	841	Morocco	1,200
Japan	2,443	Russian Federation	2,500	Kazakhstan	1,500	Ecuador	1,202	Kuwait	1,303	Spain	1,189	Nigeria	1,759
South Korea	1,200	Slovenia	1,069	Kyrgyzstan	1,500	Mexico	2,000	Lebanon	1,200	Sweden	1,206	Rwanda	1,527
Malaysia	1,300	Total	8,571	Ukraine	1,500	Peru	1,210	Qatar	1,060	United States	2,232	South Africa	3,531
Pakistan	1,200			Uzbekistan	1,500	Trinidad and Tobago	999	Turkey	1,605	Total	10,893	Zimbabwe	1,500
Philippines	1,200			Total	10,839	Uruguay	1,000	Yemen	1,000			Tunisia	1,205
Singapore	1,972					Total	11,439	Total	10,768			Egypt	1,523
Thailand	1,200											Total	17,128
Total	16,634												

Table 7 Descriptive statistics—full sample

Variable	Obs	Mean	Std. Dev	Min	Max
Life_satisfaction	85,717	6.8438	2.272891	1	10
Age	86,119	42.09281	16.56611	16	99
Age_sq	86,119	2046.238	1553.028	256	9801
High_edu	80,875	4.994077	2.174026	1	8
Gender	86,184	0.5231017	0.4994689	0	1
Single	86,037	0.2526122	0.4345129	0	1
D_employment	84,717	0.326369	0.4688868	0	1
Health	85,955	2.908836	0.852432	1	4
Income	83,194	4.890954	2.105881	1	10
Tech_beliefs	83,365	0.6793738	0.4667201	0	1
Science &Tech_beliefs	83,211	0.8323659	0.3735433	0	1
Internet_freq	81,715	0.3136633	0.4639841	0	1

Table 8 Full sample estimates

VARIABLES	Full sample
Age	-0.0307***
	(0.00302)
Age_sq	0.000370***
	(3.19e-05)
High_Edu	-0.00237
	(0.00421)
Gender	0.147***
	(0.0161)
Single	-0.221***
	(0.0224)
D_employment	0.0187
	(0.0177)
Health	0.723***
	(0.0112)
Income	0.220***
	(0.00443)
Tech_beliefs	0.337***
	(0.0286)
Internet	0.0368
	(0.0305)
Broadband	0.00115
	(0.00167)
Tech_beliefs*Broadband	-0.00813***
	(0.00141)
Internet*Broadband	0.000758
	(0.00143)
Constant	4.055***
	(0.0893)
REGION DUMMIES	YES
Observations	66,191
R-squared	0.186

Robust standard errors in parentheses

*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

Table 9 The relationship between the use of Internet, technological beliefs and SWB (ordered probit)

VARIABLES	East Asia	East Europe	Central Asia	South America	MENA	Europe—Anglo-Saxon	Africa
Age	-0.0119***	-0.0264***	-0.0226***	-0.0147***	-0.00921	-0.0228***	-0.00734*
	(0.00429)	(0.00442)	(0.00386)	(0.00390)	(0.00589)	(0.00431)	(0.00419)
Age_sq	0.000191***	0.000305***	0.000222***	0.000173***	0.000129*	0.000302***	0.000154***
	(4.57e-05)	(4.49e-05)	(3.95e-05)	(4.24e-05)	(6.79e-05)	(4.33e-05)	(4.87e-05)
High_edu	0.0262***	-0.0190***	-0.00670	-0.00584	0.000796	-0.0141**	0.0109**
	(0.00534)	(0.00667)	(0.00611)	(0.00569)	(0.00638)	(0.00632)	(0.00510)
Gender	0.101***	0.0704***	0.100***	0.0277	0.0778***	0.0770***	0.0690***
	(0.0194)	(0.0236)	(0.0206)	(0.0224)	(0.0264)	(0.0239)	(0.0190)
Single	-0.0415	-0.175***	-0.0735**	-0.155***	-0.193***	-0.287***	0.0103
	(0.0294)	(0.0350)	(0.0331)	(0.0276)	(0.0351)	(0.0328)	(0.0244)
D_employment	0.0176	0.0202	0.0217	-0.0648***	0.0560*	-0.0517*	0.0239
	(0.0206)	(0.0264)	(0.0228)	(0.0244)	(0.0291)	(0.0272)	(0.0224)
Health	0.265***	0.444***	0.393***	0.317***	0.299***	0.594***	0.327***
	(0.0134)	(0.0180)	(0.0152)	(0.0160)	(0.0183)	(0.0179)	(0.0130)
Income	0.0640***	0.148***	0.188***	0.0120**	0.110***	0.0963***	0.141***
	(0.00495)	(0.00766)	(0.00657)	(0.00571)	(0.00767)	(0.00658)	(0.00555)
Tech_beliefs	0.240***	0.162*	0.380***	-0.00310	0.280***	-0.0540	0.0883***
	(0.0377)	(0.0972)	(0.0369)	(0.0922)	(0.0510)	(0.148)	(0.0327)
Internet	-0.224***	0.152*	-0.0685	0.282***	0.0950*	-0.268*	0.0590
	(0.0451)	(0.0872)	(0.0430)	(0.0910)	(0.0503)	(0.150)	(0.0381)
Broadband	-0.00267*	0.00673	-0.00348	-0.00223	0.00784**	-0.000117	-0.00349
	(0.00159)	(0.00431)	(0.00268)	(0.00776)	(0.00308)	(0.00422)	(0.0120)
Tech_beliefs*Broadband	-0.00827***	-0.00226	-0.0216***	0.0161*	-0.0114***	0.00329	-0.0418***
	(0.00171)	(0.00462)	(0.00297)	(0.00867)	(0.00411)	(0.00447)	(0.0137)
Internet*Broadband	0.00874***	-0.00278	0.00862***	-0.0263***	-0.000915	0.00843*	0.0171
	(0.00190)	(0.00420)	(0.00309)	(0.00850)	(0.00449)	(0.00457)	(0.0147)

Table 9 (continued)

VARIABLES	East Asia	East Europe	Central Asia	South America	MENA	Europe—Anglo-Saxon	Africa
Observations	11,859	7,744	10,486	9,451	6,521	8,115	12,015

Robust standard errors in parentheses

*** $p<0.01$, ** $p<0.05$, * $p<0.1$

Table 10 The relationship between the use of Internet, technological and scientific beliefs and SWB (ordered probit)

VARIABLES	East Asia	East Europe	Central Asia	South America	MENA	Europe—Anglo-Saxon	Africa
Age	-0.0128***	-0.0258***	-0.0226***	-0.0153***	-0.0111*	-0.0234***	-0.00875**
	(0.00435)	(0.00440)	(0.00385)	(0.00383)	(0.00588)	(0.00428)	(0.00416)
Age_sq	0.000205***	0.000294***	0.000224***	0.000179***	0.000148**	0.000305***	0.000171***
	(4.65e-05)	(4.47e-05)	(3.95e-05)	(4.16e-05)	(6.79e-05)	(4.30e-05)	(4.80e-05)
High_edu	0.0284***	-0.0215***	-0.0100	-0.00466	0.00204	-0.0192***	0.0113**
	(0.00539)	(0.00666)	(0.00609)	(0.00568)	(0.00632)	(0.00625)	(0.00509)
Gender	0.100***	0.0704***	0.0944***	0.0301	0.0687***	0.0744***	0.0765***
	(0.0196)	(0.0235)	(0.0206)	(0.0223)	(0.0263)	(0.0234)	(0.0189)
Single	-0.0336	-0.193***	-0.0740**	-0.153***	-0.205***	-0.287***	0.0194
	(0.0296)	(0.0345)	(0.0328)	(0.0275)	(0.0347)	(0.0323)	(0.0243)
D_employment	0.00123	0.0151	0.0223	-0.0690***	0.0469	-0.0500*	0.0321
	(0.0209)	(0.0263)	(0.0227)	(0.0243)	(0.0289)	(0.0269)	(0.0223)
Health	0.260***	0.442***	0.391***	0.320***	0.305***	0.586***	0.320***
	(0.0136)	(0.0179)	(0.0151)	(0.0159)	(0.0182)	(0.0178)	(0.0129)
Income	0.0592***	0.150***	0.188***	0.0101*	0.105***	0.0940***	0.136***
	(0.00503)	(0.00766)	(0.00656)	(0.00569)	(0.00766)	(0.00653)	(0.00551)
Science&tech_beliefs	0.493***	0.594***	0.166***	0.170*	0.318***	0.265	0.249***
	(0.0471)	(0.134)	(0.0531)	(0.0954)	(0.0583)	(0.198)	(0.0483)
Internet	-0.226***	0.128	-0.0758*	0.282***	0.115**	-0.247*	0.0620
	(0.0450)	(0.0864)	(0.0428)	(0.0901)	(0.0494)	(0.148)	(0.0378)
Broadband	0.00212	0.0238***	-0.0160***	0.0157*	0.00240	0.00129	-0.0275
	(0.00209)	(0.00663)	(0.00402)	(0.00853)	(0.00423)	(0.00609)	(0.0173)
Science&tech_beliefs*Broadband	-0.0138***	-0.0247***	-0.00379	-0.0100	-0.00239	-0.00228	-0.00154
	(0.00217)	(0.00676)	(0.00417)	(0.00929)	(0.00470)	(0.00611)	(0.0181)
Internet*Broadband	0.00932***	-0.00129	0.00902***	-0.0265***	-0.00271	0.00799*	0.00412
	(0.00190)	(0.00417)	(0.00307)	(0.00842)	(0.00443)	(0.00446)	(0.0146)

Table 10 (continued)

VARIABLES	East Asia	East Europe	Central Asia	South America	MENA	Europe—Anglo-Saxon	Africa
Observations	11,562	7,778	10,518	9,513	6,552	8,281	12,171

Robust standard errors in parentheses

*** $p<0.01$, ** $p<0.05$, * $p<0.1$

Acknowledgements We wish to thank Gianluca Grimalda and Giuseppe Vittucci Marzetti for their helpful suggestions. We also thank the participants in the 3rd Sophia Seminar in Economics and Managment (2019) and in the 3rd ECMCRC Workshop in Dublin (2019) where previous versions of the article have been presented. Remaining errors are solely the responsibility of the authors.

Funding Open access funding provided by Università di Pisa within the CRUI-CARE Agreement.

Data availability statement The data that support the findings of this study are available upon request from the World Values Survey (https://www.worldvaluessurvey.org/wvs.jsp).

Declarations

Conflicts of interest/Competing interests The authors declare that they have no conflict of interest.

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