Journal of Innovation & Knowledge 6 (2021) 58–68

Journal of Innovation & Knowledge

https://www.journals.elsevier.com/journal-of-innovation-and-knowledge

Regular article

Does sharing economy promote sustainable economic development and energy efficiency? Evidence from OECD countries

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ARTICLE INFO

Article history:
Received 30 June 2020
Accepted 15 November 2020
Available online 3 December 2020

Keywords:
Sharing economy
Sustainable economic development
Energy efficiency

ABSTRACT

The sharing economy is a new phenomenon considered to stimulate sustainable practices. It is viewed as the synergy between technology, information and marketing that promotes a new culture where customers favor access over ownership enabling them to use resources more efficiently. Therefore, it represents an innovative business model that can act as a potential pathway to sustainable economic development and energy efficiency. However, economic, and ecological impacts of the sharing economy remain controversial and need further investigation. In fact, sharing economy has disrupted the prevailing economic paradigm soliciting questions about the advantages and the risks of this new behavior. This study aims to fill this gap in the literature and quantitatively assesses the potential implications that the sharing economy has on sustainable economic development and energy efficiency. It builds a proxy indicator for the annual level of sharing economy use per country using internet search data from Google Trends. In addition, it uses annual secondary data for a balanced panel of 18 OECD countries for the period 2014–2018 to test the proposed models' hypotheses. The positive impacts of the sharing economy on sustainable economic development and energy efficiency are supported by the results of the fixed effect regressions with Driscoll-Kraay standard errors. The findings suggest that the sharing economy represents a socio-economic trend that has the potential to stimulate sustainable economic development and energy efficiency. Therefore, they highlight the power of the sharing economy and offer important theoretical and practical implications for researchers, individuals, and policy makers.

Introduction

Sustainable development and energy efficiency are becoming major concerns for several governments (IEA, 2020; Prasetyo & Kistanti, 2020; Wilkinson, 2020) especially after a significant increase in natural resources exploitation that causes severe environmental problems (Hoang, Black, Knuteson, & Roberts, 2019; Lampert, 2019; Surya, Syafri, Sahban, & Sakti, 2020). Our economic systems highly depend on the environment; the traditional business activities that respond to the market demands would affect the consumption of natural resources and disrupt environmental systems (Arora, 2018; Majeed & Ozturk, 2020). Such environmental deterioration leads to higher resource prices and could affect the economic growth and damage environmental systems (Andrée, Chamorro, Spencer, Koomen, & Dogo, 2019). This fact calls for new innovative methods, supported by information and communication technology (ICT), to change the dominant unsustainable consumption of resources by disassociating the natural resources usage from economic growth (Gössling & Hall, 2019; Saleem & Puppim de Oliveira, 2018). Thus, gaining greater economic value by reusing material and reducing energy resource inputs (Lombardi & Schwabe, 2017; Polasky et al., 2019; Von Weizsäcker et al., 2014).

Today, technological innovations enable efficient use of resources (Aebischer & Hilty, 2015; Liang, Wang, Luo, Wei, & Sun, 2020). With technological advancements, digital platforms provide faster, less expensive, and innovative ways for practicing commerce and trading. A very good example of such a technological innovation is the sharing economy that encourages people to share existing less-frequently used resources (Hira & Reilly, 2017). Sharing economy fosters new business models that enable innovative ways for the use of resources (Curtis & Mont, 2020; Laukkanen & Tura, 2020; Sutherland & Jarrahi, 2018) and promotes sustainable growth and energy efficiency (Kaushal, 2018; Munoz & Cohen, 2017).

The sharing economy is defined as "a peer-to-peer based sharing of access to goods and services, which are facilitated by a community-based online platform" (Mi & Coffman, 2019). It is

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https://doi.org/10.1016/j.jik.2020.11.001

"a rising pattern in consumption behavior" undergoing "immense growth" (Fagerstrøm, Pawar, Sigurdsson, Foxall, & Yani-de-Soriano, 2017). Sharing economy is expected to yield several societal advantages such as saving and/or making more money (Fang, Ye, & Law, 2016; Heo, 2016), helping to change consumer behavior (Nerinckx, 2016), decreasing the resource use and promoting more sustainable consumption practices (Heinrichs, 2013; Phipps et al., 2013), as well as paving the way to sustainable economic growth (Bonciu & Balgar, 2016). Hence, sharing economy appears to be associated with positive socio-economic and environmental benefits as it is assumed to offer a step towards cost-effective practices and resource-efficient use in societies. Further, it is expected to provide several benefits including resources savings, higher standards of living, wider access to goods and services at lower costs as well as offering new income streams (Bellin, 2017; Plepys & Singh, 2019).

Research on sharing economy pertaining to economic sustainability and energy efficiency triggered some academic debate (Cherry & Pidgeon, 2018; Hamari, Sjöklint, & Ukkonen, 2015; Hasan & Birgach, 2016; Liu, Feng, Wang, & Guo, 2019). Some studies stress that only rare empirical research evidence targets the effect of the sharing economy on economic sustainability (Demailly & Novel, 2014; Geissinger, Laurell, Öberg, & Sandström, 2019) and that the research gap in investigating this topic still exists (Laurenti, Singh, Miguel, Toni, & Sinha, 2019; Leung, Xue, & Wen, 2019; Martin, 2016). Other works state that depending on how products or services are consumed, and the way things are shared, the sharing may push people to consume more energy (Jonas & Artho, 2019). In addition to the above, there exist several analytical or qualitative studies that discuss the importance of the sharing economy as an economic model that realize better sustainable consumption practices (Curtis & Mont, 2020; Frenken & Schor, 2017); however, the evidence of the costs and benefits of the sharing economy remains inconclusive (Codagnone & Martens, 2016; Martens, 2016). Further, some studies argue that the sharing economy has transformed and disrupted the standard patterns of production and consumption (Boutueil et al., 2019; Li, 2020; Pouri & Hilty, 2018) that might contribute to higher consumer benefits and provide better economy with energy saving and minimal harm to the environment (Skjelvik, Erlandsen, & Haavardsholm, 2017).

This recent surge in sharing economy has generated a debate of its advantages and drawbacks (Schor, 2016). In fact, the sustainability potential of the sharing economy is assumed to be positive and the environmental benefits are often taken for granted and directly related to a higher resource efficiency and energy saving (Curtis & Lehner, 2019; Curtis & Mont, 2020; Frenken & Schor, 2017). Nevertheless, the potential benefits of the sharing economy could be weakened through regulatory or legal frameworks (Ritter & Schanz, 2019). The overall impacts of sharing economy on economic growth, employment or the environment remain under investigated and a better understanding of these effects is required to reinforce policies that should promote sustainable and impactful evolution of the sharing economy (Plepys & Singh, 2019). Therefore, the sharing economy implications on energy efficiency and economic sustainability remain controversial; and thus, exploring such implications needs further study (Leung et al., 2019; Martin, 2016).

Finally, a publication by OECD (2019) noted that the sharing economy is not yet well measured and that it currently represents a relatively small share of the economy; nevertheless, the context of this study remains important particularly that sharing economy has been expanding rapidly within OECD countries and in some jurisdictions it might significantly influence some parts of the traditional economy (OECD, 2019). In addition, Vaughan and Daverio (2016) estimated that sharing economy generated 4 billion euros in revenues in 2015 within the European Union. Goudin (2016) predicted that the possible gains from removing barriers to promote the use of underutilized goods could be of the order of 572 billion dollars per year within the European Union.

This study adopts a quantitative approach to assess the potential implications that the sharing economy has on sustainable economic development and energy efficiency. Using annual secondary data for a balanced panel of 18 OECD countries for the period between 2004 and 2018, it builds a proxy indicator for the annual level of the use of sharing economy platforms per country based on their popularity as keywords in Google Trends search engine. To test the proposed hypotheses, it uses the fixed effect model with Driscoll-Kraay standard errors that are heteroscedasticity and autocorrelation-consistent and robust to general forms of cross-sectional and temporal dependence. Towards this end, two empirical models are proposed. The first model aims to depict if the increase in the sharing economy use will contribute to the growth of the gross domestic product per capita; further, it controls for the impacts of other variables namely, inflation, unemployment, school enrolment for primary education and population growth which might influence the gross domestic product. The second model explores if the rise in the sharing economy use reduces the energy intensity therefore leading to a higher energy efficiency. It also accounts for other control variables such as the gross domestic product per capita, energy prices and population growth.

This work contributes to the literature related to the sharing economy across several dimensions. First, it is considered among the few that attempt to measure the level of the sharing economy use by constructing a new proxy indicator for the level of use of sharing economy platforms. Second, it also contributes to the ongoing debate in the literature tackling the sustainability implications of the sharing economy by assessing the impact of sharing economy use on the sustainable economic development measured by the level of gross domestic product per capita as well as exploring the effect that sharing economy use has on energy efficiency measured by energy intensity. Third, it helps to fill the gap in the sharing economy literature by presenting a quantitative study that links the sharing economy to both sustainable economic development and energy efficiency. Therefore, this study offers the empirical evidence needed to suggest that the sharing economy has the potential to contribute to sustainable economic development and energy efficiency and provides important theoretical and practical implications for researchers, policy makers and individuals.

This rest of the paper is organized as follows. Section 2 displays the literature review. Section 3 describes the research methodology. The results are presented and discussed in Section 4. Section 5 presents the theoretical and practical implications and contributions. Section 6 highlights the limitations and the future research venues. The conclusion is presented in Section 7.

Literature review

Definition of sharing economy

Literature provides several definitions of the sharing economy. Clauss, Harengel, and Hock (2019)), define the sharing economy as platform-based models that allow the shift from an ownership society to a sharing one. Other researchers define the sharing economy as an economic model enabled and facilitated by the Internet, Web 2.0, and that allows individuals to share access to under-utilized goods or services for monetary or nonmonetary benefits (Ferrell, Ferrell, & Huggins, 2017; Richter, Kraus, Brem, Durst, & Giselbrecht, 2017). Further, the sharing economy is the synergy of technological innovation, entrepreneurship and knowledge that have been widely acknowledged as the main base of economic competitiveness and growth (Piñeiro-Chousa, López-Cabarcos, Romero-Castro, & Pérez-Pico, 2020). This work assumes the definition of sharing economy as "an economic system in which assets or services are shared by means of the Internet between private individuals, either free or for a fee, with the intention of making efficient use of society resources that encourage moving towards a more sustainable economic mode of consumption" (Dabbous & Tarhini, 2019).

The following subsections present previous literature that helps assess the sharing economy sustainability implications on economic development and energy efficiency. Thereby, two empirical models are suggested. The first model aims to depict if the increase in the sharing economy use will contribute to the growth of the gross domestic product per capita. The second model explores if the rise in the sharing economy use reduces the energy intensity therefore leading to a higher energy efficiency.

The sharing economy and sustainable economic development relationship

This subsection explores the relation between the sharing economy use and sustainable economic development. Literature on sharing economy shows a series of debates as to whether the sharing economy can yield equitable and sustainable development of the economy (Schor, 2016; Williams & Horodnic, 2017). Some studies present sharing economy as a sustainable economic model (Hasan & Birgach, 2016) and as a driver for the sustainable economic development (Heinrichs, 2013) as it increases the standards and the quality of life by allowing the use of existing resources (Bonciu & Balgar, 2016). In addition, several scholars believe that the sharing economy is cost saving (Liu & Chen, 2020; Plewnia & Guenther, 2018; Zhao, 2015) and that it reduces inequality by providing incomes to people from all social classes (Fraiberger & Sundararajan, 2015; UN, 2020). On the other hand, other scholars question the real impact that the sharing economy has on the sustainable economic growth. For instance, Hamari, Sjöklint, and Ukkonen (2015) indicate that the sharing economy does not necessarily generate sustainability; it can foster sustainable practices and at the same time strengthen the presence of unsustainable economic paradigms (Martin, 2016). It further might lead to the disruption of government regulations and to the possible monopolization of these new sharing economy firms (Cheng & Edwards, 2019; Williams & Horodnic, 2017). Other works questioned the huge fortunes made by venture investors (Schneider, 2014; Schor, 2016), and argue that sharing economy is vulnerable to monopoly and conspiracy (Matzler, Veider, & Kathan, 2015; Qiang, Bian, & Liu, 2016; Zervas, Proserpio, & Byers, 2015) and that it "reflects the intensification of an ongoing neoliberal trend that misuses the concept of entrepreneurship" (Ahsan, 2020, p. 19). Further, for some researchers, organizations are essential but unrecognized players in the sharing economy (Mair & Reischauer, 2017); it is not clear how sharing economy redefines the roles of consumers (Cheng, 2016); it is likely that sharing economy would transform employment and working conditions for the workforce mainstream to conditions similar to the working classes in high-income countries (Muntaner, 2018). This triggers questions on inequality increase and raises doubts of whether the sharing economy positively contributes to sustainable economic development.

Accordingly, this study attempts to assess whether the sharing economy use (SEU) has a real positive impact on sustainable economic development represented by the gross domestic product per capita (GDPPC). It therefore tests the following main hypothesis:

H1. SEU has a positive influence on GDPPC

In fact, sustainable economic development refers to the continuity without a large fluctuation in the rate of economic growth and targets to ensure that future generations will not suffer from diminishing resources (Ioan et al., 2020). According to Armeanu, Vintilă, and Gherghina (2018)), sustainable development comprises three principles of economic, social, and environmental growth. In addition, they advocate that sustainable economic development is improved with higher income reflected by the gross domestic product, which in turn transmits into per capita income and enhances the living standards and savings. Therefore, gross domestic product can act as a proxy for sustainable economic development. Furthermore, the gross domestic product per capita has been widely used as an indicator of sustainable economic development (Arias, 2006; Fernández-Portillo, Almodóvar-González, Coca-Pérez, & Jiménez-Naranjo, 2019; Vasylieva, Lyulyov, Bilan, & Streimikiene, 2019).

The sharing economy and the energy efficiency relationship

This subsection tackles the relation between the sharing economy use and the energy efficiency. Previous literature shows a growing debate related to the impact of sharing economy on sustainable economic development and the environmental benefits (Chan, Chang, Lau, Law, & Lei, 2016; Zmyślony, Leszczyński, Waligóra, & Alejziak, 2020). Energy efficiency is assumed to enhance competitiveness and productivity (Rajbhandari & Zhang, 2018). Various studies claim that the sharing economy helps to save energy, reduce waste, carbon footprints and emissions (Belk, 2014; Leismann, Schmitt, Rohn, & Baedeker, 2013; Plewnia & Guenther, 2018) while other researchers assert the opposite (Jonas & Artho, 2019). It is believed that the sharing economy decreases the overall consumption and the associated level of resources usage (Ala-Mantila, Ottelin, Heinonen, & Junnila, 2016; de Leeuw & Gössling, 2016) and that the overconsumption of natural resources is the main reason for environmental change (Piscicelli, Cooper, & Fisher, 2015; Surya et al., 2020). Yet, some scholars argue that there is not much empirical research to judge whether sharing platforms reduce the environmental impacts in the long-term (Demailly & Novel, 2014; Ganapati & Reddick, 2018).

Furthermore, since sharing economy is enabled by ICT-based platforms, it inherits the ICT impact on environment and energy consumption. Literature shows that only few researches address the ICT software sustainability with respect to energy efficiency and natural resources consumption (Guldner et al., 2018; Kern, 2018). Such studies agree that ICT equipment consumes energy and resources at different stages in the supply chain (Coroama & Hilty, 2014; Hilty, Lohmann, & Huang, 2011). In fact, due to the growing demand of ICT applications, energy consumption of ICT is still increasing, and it overcame all measures taken to improve energy efficiency (Aebischer & Hilty, 2015; Alshubiri, Jamil, & Elheddad, 2019). This is highly related to sharing economy, where its software applications require remarkable hardware requirements and data centers that considerably demand natural resources exploitation and energy consumption. On the other hand, some supporters of sharing economy believe that in the long run, sharing would save more energy because sharing offers a sustainable, and less resource consumption model by selling the service rather than the product (Belk, 2014; Matzler et al., 2015). This raises questions of whether the sharing economy positively contributes to energy efficiency.

Hence, this study assesses if the sharing economy use has a real positive impact on energy efficiency, using the energy intensity as a proxy. Therefore, it explores if SEU has a negative impact on energy intensity (EI) and tests the following main hypothesis:

H2: SEU has a negative impact on EI

Several studies used the concept of energy intensity defined as the as total final energy consumption divided by GDP to describe the level of energy efficiency (Adom, 2015; Fitriyanto & Iskandar, 2019; Metcalf, 2008; Rajbhandari & Zhang, 2018). This study follows Rajbhandari and Zhang (2018); it uses energy intensity, which is defined as energy use per unit of economic output, as a proxy for energy efficiency A decrease in energy intensity is interpreted as an increase in energy efficiency.

Research methodology

Control variables and models' specification

Model 1 assesses if SEU exerts a positive impact on GDPPC. It also accounts for the influence of four macroeconomic factors that might influence the sustainable economic development measured by the GDPPC, namely inflation, unemployment, school enrolment for primary education and population growth.

In fact, despite the vast literature investigating the association between population growth and economic development (Boldeanu & Constantinescu, 2015), population dynamics and its impacts on economic outcomes is still a subject of major debates (Dauda & Aziakpono, 2015). Some scholars argue that population growth plays an important role in every country's economic growth and show that it has a positive impact on economic development in the long-run (Degu, 2019; Rehman & Deyuan, 2018; Sebikabu, Ruvuna, & Ruzima, 2020). Kitov (2006) shows that the real GDPPC observed changes can be explained by the population component fluctuations. On the other hand, some researchers argue that population growth may hinder economic development, yielding lower economic growth (Ahlburg & Cassen, 2008; Garza-Rodriguez, Andrade-Velasco, Martinez-Silva, Renteria-Rodriguez, & Vallejo-Castillo, 2016), while some still question the role played by population in the economic growth path (Furuoka, 2018). This study therefore accounts for the impact of population growth on the GDPPC.

In addition, the literature discusses the connections between economic growth, inflation, and unemployment. Some studies advocate that inflation represents a constraint for economic growth (Bhaskara-Rao & Hassan, 2011). Haseeb, Zandi, Hartani, Pahi, and Nadeem (2019)) argue that an increase in inflation reduces the supply chain activities which decreases economic growth. Sahnoun and Abdennadher (2019) establish a unidirectional causality running from inflation to economic growth in North African countries. Other scholars argue that inflation promotes growth (Benhabib & Spiegel, 2009; Rapach, 2003). Finally, Adaramola and Dada (2020) show that there is no causal relationship between inflation and gross domestic product. Other studies argue that inflation does not influence economic growth (Dorrance, 1966; Sidrauski, 1967). Hence, this study accounts for the impact of inflation on economic growth.

Furthermore, Ojima (2019) establishes that unemployment negatively influences economic development. Mohseni and Jouzaryan (2016) find a significant and negative impact of inflation and unemployment on economic growth in long run. Dritsakis and Stamatiou (2016) show that a unidirectional causal relationship exists between unemployment and economic growth. Shahid (2014) empirical results reveal that a long run relationship between unemployment and economic growth exists in Pakistan. Meidani and Zabihi (2011) demonstrate that the unemployment rate is a statistically significant factor that determines the real GDPPC in the long run. Unemployment is therefore an important factor to account for when exploring the influence of sharing economy on economic development.

Finally, education, as an investment in human capital, is considered as an essential determinant of sustainable economic growth (Jorgenson & Fraumeni, 1992). Liao, Du, Wang, and Yu (2019) demonstrate that a feedback causality exists between education and sustainable economic growth in Guangdong province by using the panel data of 21 cities from 2000 to 2016. Tsamadias and Prontzas (2012) reveal that education has a significant positive impact on economic growth in Greece. Afzal, Rehman, Farooq, and Sarwar (2011) establish a feedback causality between education and economic growth in Pakistan. Hence, the model accounts for the influence of education on economic development. Drawing on this literature the following model is proposed:

GDPPC = f (SEU, ERP, POPG, UNP, INF),

where, *ERP, POPG, UNP and INF represent* school enrolment in primary education, population growth, unemployment rate and inflation rate, respectively.

Model 2 explores if there is a positive relation between SEU and energy efficiency. Therefore, it assesses if SEU has a negative impact on EI. Furthermore, it accounts for three other control variables, the GDPPC, energy prices and population growth. The relations between EI, economic growth and energy prices have been previously explored. Akal (2016) and Agovino, Bartoletto, and Garofalo (2019) conclude that total EI and GDPPC are related. Azhgaliyeva, Liu, and Liddle (2020) show that higher GDPPC and energy prices lead to lower EI using data from 44 countries over the years 1990–2016. Fitriyanto and Iskandar (2019) indicate that GDPPC and energy prices have a significantly negative impact on EI in nine Southeast Asian countries during the period of 2001−2014. Rajbhandari and Zhang (2018) show that for all income groups gross domestic product growth and higher energy prices are negatively correlated with EI for a panel of 56 high- and middle-income economies for the period 1978−2012. The empirical research conducted by Deichmann, Reuter, Vollmer, and Zhang (2018) reveal that for a panel data set of 137 economies during 1990–2014, EI is negatively correlated with GDPPC. Adom (2015) advocates that energy price is a factor that affects EI. Mahmood and Ahmad (2018) find negative relations between economic growth, energy prices and EI in a study among 19 countries. Filipović, Verbi, and Radovanovi (2015) show that energy price, energy tax and GDPPC negatively influence EI in OECD countries and that energy prices had the most influence on EI in the European Union. Therefore, it is essential to control for gross domestic product and energy prices while investigating the impact of the SEU on EI.

In addition, population growth also influences EI through its impact on energy consumption. Avtar, Tripathi, Aggarwal, and Kumar (2019) explore the energy–urbanization–population nexus and reveal that as the global population growth rate and life expectancy increased steadily, the demand for electricity has risen exponentially. Lam, Kenway, Lane, Islam, and de Berc (2019) show that population growth and per capita demand for imported commodities represent two important factors for higher energy use in Australia for the period 2006–2015. Rezki (2011) finds that GDPPC and population have a positive influence on energy consumption in the Southeast Asian region in the period of 1990– 2004. Metcalf (2008) establishes that both price and per capita income negatively influence EI, while population has a positive effect on EI in the United States within the period of 1970−2003. Accordingly, the population growth is added as a variable that could have an impact on EI.

Finally, this study uses the consumer price index (CPI) as a proxy for energy prices particularly that energy prices are not available for all the countries included in the sample for the period 2014−2018. In addition, the CPI which measures the fluctuations in the price of a typical basket of consumer goods and services had been widely used as a proxy for energy prices within the energy literature (Carfora, Pansini, & Scandurra, 2019; Chang, 2015; Elheddad, Djellouli, Tiwari, & Hammoudeh, 2020; Murad, Alam, Noman, & Ozturk, 2019). Drawing on this literature the following model is proposed:

EI = f (SEU, GDPPC, CPI, POPG),

where, *CPI, and POPG represent* energy prices proxied by the consumer price index and population growth rate, respectively.

Construction of the proxy indicator

This study follows Rivares, Gal, Millot, and Sorbe (2019)) who assume that a platform that is highly used will be greatly searched for in Google. Particularly this study adopts their innovative technique and applies it in the context of the sharing economy. Therefore, it builds a proxy measure for the platform's development based on their popularity as keywords in the google trends search engine. Google Trends presents the data on a normalized scale, specific to each query, with the maximum data point equal to 100. For each country in the sample, the measure for SEU indicator is constructed by summing within each country and for each year the share of google searches related to the name of a selection of sharing economy platforms. Specifically, for each country a list of sharing economy platforms was identified based on a scanning exercise for all possible sources that tackle the subject of the sharing economy across OECD countries and several articles in the sharing economy literature (Fellander, Ingram, & Teigland, 2015; Stanoevska-Slabeva, Lenz-Kesekamp, & Suter, 2017; Vaughan & Daverio, 2016). Table A1 in Appendix A provides the references for all sources used to select the sharing economy platforms in each country. The selection is not meant to be exhaustive but it aims to construct an indicator that captures the main platforms of the sharing economy operating in each country and to create an appropriate indicator for the overall level of use of the sharing economy. To build a relevant indicator, the final sample consisted of 18 OECD countries for the period between 2004 and 2018. The sample included only countries for which the authors were able to capture the main operating sharing economy platforms and to collect the required data for the period between 2004 and 2018. Table A2 in Appendix A provides a list for the OECD countries used in this study and the number of sharing economy platforms included in the sample for each of these countries.

The data from google insights for search has been widely used in the literature. Askitas and Zimmermann (2009) used this type of data in employment and skills studies. Preis, Moat, and Stanley (2013)) used it in the context of analyzing the trading behavior in the financial markets. Moreover, it is used to forecast economic variables like retail good consumption or travel activities (Carrière-Swallow & Labbé, 2013; Robin, 2018; Von Graevenitz, Helmers, Millot, & Turnbull, 2016).

Sample and data collection

In addition to the SEU indicator constructed by the authors, the data used in the empirical analysis includes annual secondary data for a balanced panel of 18 OECD countries for the period between 2004 and 2018. This study uses seven types of data in the analysis. Data on the energy efficiency was represented by EI as a proxy and measured as total final energy consumption divided by GDP. The data was collected from the world bank development indicators (WDI) database and from the united nations sustainable development goals indicators database (UNSD SDG database). The time series data for the GDPPC, ERP, CPI, POPG, UNP and INF were all retrieved from the world bank development indicators (WDI) database. The descriptive statistics of the variables used in this study are provided in Table 1. The results show that unemployment and inflation have the highest variability as indicated by the large standard deviations for these variables. The authors also conduct logarithmic transformations for the SEU, GDPPC, EI, ERP and CPI. The logarithmic transformations performed allow the comparability across the different explanatory variables. The average values per country for the years 2004–2018 for the SEU indicator, GDPPC and EI which represent the three main variables in this study are presented in Table A3 in Appendix A. As shown in Table A3, the highest average level for SEU indicator was observed in the United Kingdom, whereas the lowest average value was detected in Ireland. As for the GDPPC, the highest average was observed in Norway, while Hungary scored the lowest average for the years 2004–2018. In addition, Norway also ranked first in terms of EI with the highest average for the study period, while Ireland presented the lowest average.

Table 1
Summary statistics.

	Mean	Std. Dev.	Minimum	Maximum
INF	1.84365	1.44873	−4.47810	7.95875
POPG	0.558887	0.638617	−1.85371	2.89096
UNP	8.23312	4.68811	2.49300	27.4660
LGDPPC	10.6094	0.273437	9.77697	11.3024
LSEU	6.89357	0.651875	5.50160	8.55523
LEI	1.50250	0.255561	0.629059	1.95652
LERP	4.63069	0.0453351	4.54892	4.85437
LCPI	4.61299	0.0836149	4.30771	4.76982

Panel data analysis

This study uses a balanced panel of 18 OECD countries for the period between 2004–2018 to test the proposed models. The main advantage of using a panel data is that it allows the researcher to have a greater flexibility in modeling differences in behavior across the units. Panel data also provides more variability, less collinearity among the variables, higher degrees of freedom and more efficiency (Baltagi, 2005). Stata 14 statistical software is used to conduct the empirical analysis. The first step consists of calculating the variance inflation factors (VIF) for the variables in each of the two models considered to detect possible multicollinearity. The results indicate that all VIF were less than the threshold of 4, suggesting that no multicollinearity exists among the variables considered in this study for both models. In addition, the Jochmans and Verardi (2019) Portmanteau test for serial correlation in a linear panel model is conducted for both models. This test is designed for short panels and allows for heteroscedasticity. The results of the portmanteau tests for both models provide strong evidence of no presence of serial correlation in the errors.

Next, given the small sample size of 18 cross-sectional units and 15 time periods, the balanced panel in this study can only be estimated using either the pooled ordinary least square (OLS) technique, the fixed effect or the random effect estimators (Baltagi, 2005). A pooled (OLS) regression has constant coefficients, showing both intercepts and slopes. For the random effect model, the individual effects are randomly dispersed across the cross-sectional units to capture the individual effects. The model is characterized by an intercept term constant across all units. The fixed effect estimator is used when the only interest is to analyze the impact of variables that vary over time. This estimator investigates the relation between the predictor and outcome variables within a unit. Each unit is characterized by its own individual characteristics that may or may not affect the predictor variables. In the regression model the intercept term represents the fixed country effect. Since the cross-sectional samples are relatively small it is appropriate to use the fixed effect model to estimate the parameters (Seddigi & Lawler, 2000). However, this study also provides the necessary tests to choose the appropriate model to use. To select the appropriate estimation technique, this study runs two tests, an F-test for joint significance of differing group means which allows to choose between the pooled OLS model and the fixed effect model and a Hausman test which shows whether the fixed effect model is the appropriate one to use or the random effect one. The results of the F-test for the joint significance of differing group means for both models indicate very low p-values $F(17, 247) = 371.318$ with p-value 4.37887e-165 for model

Table 2
Empirical results for Eq. 1. Model 1: Fixed effects, using 270 observations. Regression with Driscoll-Kraay standard errors. Included 18 cross-sectional units. Time-series length = 15. Dependent variable: LGDPPC.

	Coefficient	Drisc/Kraay Std. Error	t-ratio	p-value
const	9.258631	0.2854379	32.44	0.000
LSEU	0.0716147	0.0061224	11.70	0.000
LERP	0.221527	0.0579216	3.82	0.001
POPG	−0.0312555	0.0105089	−2.97	0.009
UNP	−0.0181212	.0020515	−8.83	0.000
INF	−0.0011028	.002472	−0.45	0.661

Table 3
Empirical results for Eq. 2. Model 2: Fixed effects, using 270 observations. Regression with Driscoll-Kraay standard errors. Included 18 cross-sectional units. Time-series length = 15. Dependent variable: LEI.

	Coefficient	Std. Error	t-ratio	p-value
const	9.669895	0.2103529	45.97	0.000
LSE	−0.0586842	0.009367	−6.27	0.000
LGDPPC	−0.5711243	0.0377612	−15.12	0.000
LCPI	−0.3725462	0.0658014	−5.66	0.000
POPG	0.0268514	0.0078555	3.42	0.003

1, and F (17, 247) = 485.409 with p-value 1.70401e-179 for model 2, therefore the null hypothesis that the pooled OLS model is appropriate is rejected and the fixed effect one should be used. Furthermore, the Hausman tests results for model misspecification reveal that the fixed effect model is the appropriate technique to use to estimate both models. The p-values for the Hausman tests for both models, H = 20.7464 with p-value = prob (chi-square (5) > 20.7464) = 0.000904455 for model 1and H = 12.82 with p-value = prob (chi-square (4) > 12.82) = 0.0121897 for model 2, were less than 0.05, therefore the fixed effect model should be used.

Hence the following two fixed effect models will be estimated:

$$LGDPPC_{it}=\beta_0+\beta_1\mathrm{LSEU_{it}}+\beta_2\mathrm{LERP_{it}}+\beta_3\mathrm{POPG_{it}}+\beta_4\mathrm{UNP_{it}}+\beta_5\mathrm{INF_{it}}+\mathrm{v_i}+\varepsilon_{\mathrm{it}} \quad (1)$$

$$LEI_{it}=\beta_0+\beta_1\mathrm{LSEU_{it}}+\beta_2\mathrm{LGDPPC_{it}}+\beta_3\mathrm{LCPI_{it}}+\beta_4\mathrm{POPG_{it}}+\mathrm{v_i}+\varepsilon_{\mathrm{it}} \quad (2)$$

where, L refers to the natural logarithm; $i = 1\ldots, N$ shows the subscript for each country included in the panel, and $t=1\ldots, T$ shows the time period, ν_i indicates the country specific effect and ε_{it} refers to the random error term. To obtain tractable empirical models and to facilitate the interpretations the logarithmic transformation for all the variables was taken except for inflation rate, unemployment, and population growth.

However, one of the drawbacks for using panel data is the presence of cross-sectional dependence and/or heteroscedasticity which may yield misleading inference. To overcome this limitation this study tests for cross-sectional dependence (CD) using the Pesaran CD test. In addition, the Wald test for groupwise heteroscedasticity in the residuals of a fixed effect regression model is conducted for both models (Greene, 2000). The results for the Pesaran CD show the existence of cross-sectional dependence for both models (Pesaran CD test statistic = 8.967, Pr = 0.000 for model 1 and Pesaran CD test statistic = 1.957, Pr = 0.0503). In addition, the results for the Wald statistic for groupwise heteroscedasticity in a fixed effect regression reject the null of homeskedsticity for both models (chi2 (18) = 996.81, Prob > chi2 = 0.000 for model 1 and chi2 (18) = 707.38, Prob > chi2 = 0.000 for model 2). Hence, to investigate the impacts of sharing economy use on sustainable economic development and energy efficiency, the panel fixed effects model with Driscoll-Kraay standard errors was used. The Driscoll-Kraay standard errors are heteroskedasticity- and autocorrelation-consistent and robust to general forms of cross-sectional and temporal dependence (Hoechle, 2007).

Results and discussion

Empirical results

This section examines the estimation results for the panel fixed effects (FE) models with Driscoll-Kraay standard errors. The empirical results for Eqs 1 and 2 are presented in Tables 2 and 3. In Table 2, the sharing economy appears to positively contribute to the sustainable economic development as shown by the positive impact it has on the GDPPC. The SEU indicator has a significant positive influence on the GDPPC at the 5 percent significance level ($\beta 1 = 0.0716147$, $p = 0.000$) indicating that if the sharing economy use increases across OECD countries by 1% the GDPPC will also increase by 0. 0716% and that the sharing economy does influence the sustainable economic development. Thus, Hypothesis H1 is validated.

As for the remaining explanatory variables, their estimated coefficients are all statistically significant at the 5 percent significance level except for the inflation whose impact is negative but not significant for the time period studied in this paper (β_5=-0.0011028, $p > 0.05$.) The education level represented by ERP has a significant positive impact on the GDPPC ($\beta_2 = 0.223$, $p = 0.001$) indicating that if the enrolment in primary school rises by 1% the GDPPC increases by 0.223%. Population growth appears to have a significant negative impact on GDPPC (β_3= -0.0312555, $p = 0.009$). If the population grows by 1% the GDPPC decreases by 3.12%. The unemployment has a negative significant impact on GDPPC (β_4= -0.0181212, $p = 0.000$). If the unemployment rate raises by 1% the GDPPC decreases by 1.81. Finally, the results for the F-test of overall significance F (5, 17) = 258.51 with Prob > F = 0.000 and the R-squared value of 0.6754 show that model 1 has a strong power to explain sustainable economic development.

Table 3 reveals that the sharing economy use positively contributes to the energy efficiency as shown by the negative impact it has on the energy intensity. The results highlight the fact that an increase in the sharing economy use leads to a lower energy intensity, which is a decrease in the energy consumption per unit of GDP and thus leads to higher energy efficiency. The SEU indicator has a significant negative impact on EI at the 5 percent significance level ($\beta_{1=}$-0.0586842, $p = 0.000$) indicating that if the sharing economy use across OECD countries increases by 1% the energy intensity will decrease by 0. 058% and that the sharing economy positively influences energy efficiency. Therefore, hypothesis H2 is validated.

As for the remaining control variables included in model 2, their estimated coefficients are all statistically significant at the 5 percent significance level. The GDPPC has a negative significant influence on EI and as a result if GDPPC increases the energy efficiency improves (β_2 =-0.5711243, $p = 0.000$). A 1% increase in GDPPC decreases the energy intensity by 0.571%. Energy prices represented by the CPI as a proxy have a negative significant impact on EI (β_3= -0.3725462, $p = 0.000$). If the prices increase by 1%, the energy consumption and consequently the energy intensity decreases by 0.372%. The population growth has a significant positive impact on EI ($\beta_4 = 0.0268514$, $p = 0.003$). If the population grows by 1% the energy intensity increases by 0.0268% and consequently the energy efficiency decreases. In addition, the results for the F-test of overall significance F (4, 17) = 1173.32 with Prob > F = 0.000 and the R-squared value of 0.8125 show that model 2 has a strong power to explain energy intensity.

Finally, as a robustness check, this study compares the results of both models with and without control variables (Felício, Rodrigues, Grove, & Greiner, 2018). The findings indicate that SEU exerts a significant positive impact on GDPPC when model 1 is estimated without accounting for the control variables (β_3 = .0626033, $p = 0.004$). In addition, SEU has also a significant negative impact on EI when considering model 2 without accounting for the control variables (β_3= -0.149827, p = 0.000). However, for both models the explanatory power was higher when accounting for the control variables as indicated by the lower R-squared values of 0.1898 and 0.6262 for models 1 and 2 estimated without these variables.

Results discussion

Drawing on the empirical results derived in this study, the sharing economy offers a promising opportunity to contribute to the sustainability of the society across two dimensions, economic development, and energy efficiency. The first dimension appears in the results of model 1. It establishes that sharing economy provides the opportunity to increase the sustainable economic development through its positive impact on the gross domestic product. This result is in line with Heinrichs (2013); Bonciu and Balgar (2016) and Hasan and Birgah (2016) who consider the sharing economy as a new approach that offers the potential to promote the sustainable economic development. The second dimension is explained by the results of model 2. It highlights the fact that sharing economy through facilitating the use of under-utilized resources via the sharing is expected to increase the energy efficiency. It is in line with the studies that argue that the sharing economy helps to save energy, reduce waste, carbon footprints and emissions (Belk, 2014; Leismann et al., 2013; Plewnia & Guenther, 2018). Hence, the empirical results obtained assert that the sharing economy is an economic driver that potentially generates sustainability impacts in terms of the consumption as the consumers are entitled to access resources without ownership more efficiently and in terms of the environment by enhancing the energy efficiency. It therefore matches the literature that promotes sharing economy as allowing access over ownership of goods and services which will decrease the overall consumption and the associated level of resources' use (Ala-Mantila et al., 2016; Bonciu & Balgar, 2016; de Leeuw & Gössling, 2016; Plewnia & Guenther, 2018).

In addition, model 1 empirical results show that the education level represented by the enrolment in primary education has a significant positive impact on the GDPPC, these results match previous literature that establish education as an important factor that positively influences sustainable economic development (Afzal, Rehman, Farooq, & Sarwar, 2011; Liao, Du, Wang, & Yu, 2019; Tsamadias & Prontzas, 2012). Furthermore, they are in line with the strand of literature which argues that population growth may hinder economic development, yielding lower economic growth (Ahlburg & Cassen, 2008; Garza-Rodriguez et al., 2016). As for unemployment, the empirical results confirm that a negative relation exists between gross domestic product and unemployment and are therefore in line with previous works which show this relationship (Dritsakis & Stamatiou, 2016; Mohseni & Jouzaryan, 2016; Ojima, 2019). Finally, the non-significant impact of inflation on economic development is in line with previous works that assert that there is no causal relationship between inflation and gross domestic product and that inflation does not have any influence on economic growth (Adaramola & Dada, 2020; Dorrance, 1966; Sidrauski, 1967).

Furthermore, the empirical results of model 2 which shows a negative impact of both GDPPC and energy prices on energy intensity match previous studies which establish these negative relationships (Agovino, Bartoletto, & Garofalo, 2019; Azhgaliyeva, Liu, & Liddle, 2020; Deichmann, Reuter, Vollmer, & Zhang, 2018; Filipović, Verbič, & Radovanović, 2015; Fitriyanto & Iskandar, 2019; Mahmood & Ahmad, 2018; Rajbhandari & Zhang, 2018). Finally, the results revealing the positive impact that population growth has on energy intensity are in line with the previous literature that shows that an increase in population increases energy intensity through its influence on energy consumption therefore yielding lower energy efficiency (Avtar, Tripathi, Aggarwal, & Kumar, 2019; Kaushal, 2018; Lam, Kenway, Lane, Islam, & de Berc, 2019; Metcalf, 2008; Rezki, 2011).

Theoretical and practical implications and contributions

Theoretical implications

The empirical results driven offer several theoretical implications. First, the study uses a novel technique and constructs a sharing economy use indicator for the level of use of sharing economy platforms per country based on their popularity as keywords in Google Trends search engine. It is considered among the first attempts to build a proxy for sharing economy that could be used in empirical analysis. Second, this study provides empirical evidence that helps resolving the growing debate questioning the real impact that sharing economy has on sustainable economic development (Schor, 2016; Williams & Horodnic, 2017), the environment (Chan et al., 2016; Zmyślony et al., 2020) and the energy efficiency. It also helps in understanding the population dynamics and its impacts on economic outcomes which remains a subject of major debates (Dauda & Aziakpono, 2015), particularly that some scholars still question the role played by population in the economic growth path (Furuoka, 2018). Third, despite the fact that the relation between inflation and economic growth has been widely studied in the economic literature, the results related to this relation which shows that inflation does not influence GDPPC provide an additional empirical evidence for this relation which remains controversial and open the wave for more elaborated dynamic studies.

Practical implications

The empirical results of this study yield several practical implications. First, they highlight that the sharing economy represents an efficient and essential business model that promotes sustainable consumption and production methods and therefore encourages individuals to adopt sharing economy practices. Second, the sharing economy appears as a solution to the mounting challenges facing the economies to accommodate a growing number of populations with limited resources. Therefore, policy makers are encouraged to promote the growth of this new form of economic activity. In addition, the governments have a role to play by adopting the appropriate regulations and taxation policies that enable the sharing economy models to realize their full potential in terms of sustainability gains for sustainable economic development and energy efficiency. Third, the results highlight that the sharing economy can help to reduce pollutants and carbon emissions, which will have a positive impact on the environment. The policy makers and educational institutions should raise the consumers' awareness regarding this important topic and encourage them to increasingly adopt the sharing practices that shift consumer behavior to eco-friendlier choices which reduce the environmental damages. Fourth, with the decrease in crude oil prices and the increase in the costs of renewable energy consumption, particularly for developing economies (Carfora et al., 2019), the relation between energy consumption, energy prices and economic growth is of high importance. Thus, the results of model 2 which assess the impact of sharing economy use on energy intensity while controlling for both energy prices and GDPPC offer insightful thoughts for policy makers.

Limitations and further research venue

While this research offers several contributions, it might suffer from some limitations. One of the limitations could be the sample used, as data were only collected from the OECD countries, which is considered as a limitation for the possibility of generalizing the results to other regions. Hence, it is recommended to replicate this empirical analysis for other geographical regions to investigate the influence of the sharing economy on both sustainable economic development and energy efficiency under different economic structures and various cultural contexts. Furthermore, this research uses a proxy for the level of use of the sharing economy, it is therefore interesting to wait until real secondary data that measures the size of the sharing economy becomes available to explore and derive new empirical results based on the proposed models. This step is important to explore the real potential of the sharing economy as a driver for sustainable economic development and energy efficiency. Finally, even though this study suffers some limitations, the results remain statistically significant and reliable and open the way for a new stream of research that tackles the sustainability implications for the sharing economy and its impact on the sustainable economic development and energy efficiency which is considered an important avenue for future work.

Conclusion

This study aims to investigate and empirically assess the relationships between the sharing economy use and sustainable economic development and energy efficiency. It considers that the sharing economy has the potential to be viewed as a pathway to both sustainable economic development and energy efficiency. Towards this end, this study proposes an indicator for the level of sharing economy use per country based on data collected from Google Trend search engine. In addition, secondary data for a balanced panel of 18 OECD countries was collected for the period between 2014–2018. Two empirical models that relate the sharing economy to GDPPC as a proxy for sustainable economic development and energy intensity as a proxy for the energy efficiency were proposed and tested. The models are tested using the fixed effect model with Driscoll-Kraay standard errors that are heteroskedasticity- and autocorrelation-consistent and robust to general forms of cross-sectional and temporal dependence. The results highlight the efficiency gains of the sharing economy as they provide an empirical evidence for the importance of this new system as a tool to increase both sustainable economic development and energy efficiency. Furthermore, they offer several relevant implications for research and practice and set the ground for the development of more elaborated models that investigate other dimensions for the implications of the sharing economy on sustainability.

Appendix A

Table A1
List of sources uses to select the sharing economy platforms in the OECD countries.

1- Stanoevska-Slabeva, K. and Lenz-Kesekamp, V. & Suter, V. (2017), Platforms and the Sharing Economy: An Analysis EU H2020 Research Project Ps2Share: Participation, Privacy, and Power in the Sharing Economy, 2017 (November 28, 2017). https://ssrn.com/abstract=3102184 or https://doi.org/10.2139/ssrn.3102184
2- World Economic Forum (2017), in Collaboration with PWC, white Paper, Collboration in Cities from sharing to Sharing Economy. http://www3.weforum.org/docs/White_Paper_Collaboration_in_Cities_report_2017.pdf
3- Vaughan, R. & R. Daverio (2016), Assessing the size and presence of the collaborative economy in Europe, Publications Office of the European Union.
4- Fellander, A., Ingram, C., & Teigland, R. (2015). The Sharing Economy Embracing Change with Caution. Stockholm: Entreprenörskapsforum.
5-https://www.escadrille.org/fr/blog/france-sharing-economy
6- https://www.neighbor.com/storage-blog/sharing-economy-pioneers/
7- https://www.forbes.com/pictures/54f4e71eda47a54de8245bf8/15-small-company-stocks-y/#6474e9782a50
8- https://thesquare.gent/work-in-ghent/sharing-economy-ghent/
9- https://www.dw.com/en/share-economy-nearly-four-in-ten-germans-use-online-services/a-42672631
10- https://www.ratecity.com.au/top-30-sharing-economy-sites
11- https://www.ns-businesshub.com/technology/sharing-economy-companies-list/
12- https://sharedeconomycpa.com/blog/who-are-the-top-12-pioneers-in-the-sharing-economy/
13- https://blog.liftshare.com/fun/7-sharing-platforms-uk
14- https://www.ecrowdinvest.com/blog/en/sharing-economy/
15- http://4liberty.eu/sharing-economy-in-italy-regulations-and-current-debate/
16- https://www.ratecity.com.au/top-30-sharing-economy-sites
17- https://www.bi.edu/globalassets/forskning/h2020/ps2share_platform-analysis-paper_final.pdf
18- https://www.slideshare.net/dagslet/the-sharing-economy-in-norway-nationwide-study
19- https://teknologiradet.no/en/the-sharing-economy/
20 https://delingsokonomi.dep.no/files/2015/11/NOU_2017-4_chapter_1.pdf
21- https://blog.euromonitor.com/hungary-the-painful-birth-of-the-sharing-economy/
22- https://www.xpatloop.com/channels/2018/05/sharing-economy-reloaded.html
23-http://sharingandcaring.eu/sites/default/files/files/CountriesReport2018.pdf
24- http://www.sharingskills.eu/wp- content/uploads/2016/09/SharingSkills_NationalReport_Portugal-1.pdf

This Table provides a detailed list for all the sources used by the authors to collect the sharing economy platforms for each of the OECD country included in the sample studied. A complete list of the names of the platforms can be provided by authors upon request.

Table A2
List of OECD countries and the number of the sharing economy platforms included in the sample.

Country	Platforms' Number	Country	Platforms' Number	Country	Platforms' Number
Australia	74	**Hungary**	48	**Poland**	70
Belgium	56	**Ireland**	17	**Portugal**	43
Denmark	45	**Italy**	60	**Spain**	84
France	107	**Netherlands**	67	**Sweden**	83
Germany	91	**New Zeeland**	48	**UK**	136
Greece	52	**Norway**	51	**USA**	67

This Table lists all the OECD countries included in the sample studies. It also indicates the number of sharing economy platforms used in each country which are included in the sample.

Table A3
Average values per country for the period 2004-2018 for the SEU indicator, GDPPC and EI.

Country	SEU	GDPPC	EI
United Kingdom	2759.527	41380.72	3.711963
France	1861.958	40421.55	4.432511
Germany	1582.87	45596.75	4.109422
United States	1570.157	54642.61	6.169159
Spain	1487.376	35335.52	4.051202
Australia	1477.402	45359.09	5.917209
Sweden	1378.846	46714.55	5.313687
Netherlands	1347.102	49752.74	5.384889
Poland	1157.73	23590.96	4.746617
Belgium	1151.917	45219.5	6.008854
Italy	1115.343	38767.67	3.427703
New Zealand	964.7545	35308.9	5.776342
Denmark	877.8254	48652.48	3.135251
Norway	805.2473	59951.38	6.059325
Hungary	735.6399	25299.99	4.354406
Portugal	687.127	30063.25	3.797648
Greece	661.7722	30443.87	4.283339
Ireland	362.5075	59058.5	2.758081

This Table indicates the average values per country for the SEU indicator, GDPPC and EI for the period 2004–2018. Countries are sorted from highest to lowest level of the average value of SEU.

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