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The Economic Implications of Increased Product Longevity

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Abstract: Interest in product longevity has increased across Europe in recent years. To date, however, little attention has been paid to the implications for national economies if a higher proportion of consumer durables were to be designed and manufactured for longer lifetimes, average lifetimes increased, and product replacement cycles slowed. This lack of knowledge is problematic for several reasons. First, it is important that the implications of increased product longevity for traditional economic goals such as growth, low unemployment and a satisfactory balance of trade are understood. Second, if public policy support is required for such a strategy on environmental grounds, the economic implications need to be understood in order to leverage support from governments' finance and economics departments. This paper reviews the current state of knowledge on product lifetimes from the perspective of economics, drawing upon literature from academia, public bodies and policy organisations, and including recent studies on the circular economy. It concludes that the evidence base on the macroeconomic implications of increased product lifetimes is inadequate, while noting that studies have identified potential growth, employment and trade benefits. There is also inadequate understanding of how microeconomics might be applied to product lifetimes. Too few economists have engaged with this topic; a research agenda is urgently required.

Introduction

Within a growing body of research on product longevity, scholars from many disciplines have explored consumer attitudes, behaviour and expectations towards product lifetimes, design approaches and tools, planned obsolescence, lifetime optimisation and metrics, business models and product-service systems (Cooper et al., 2015; Bakker and Mugge, 2017). By contrast, there has been negligible engagement from economists, which is problematic because if policies are put in place to encourage increased product lifetimes, the implications for traditional economic goals such as growth, low unemployment and a satisfactory balance of trade need to be understood to enable appropriate management of the economy.

The circular economy provides a suitable starting point to explore the economic implications of increased product longevity. The concept can be traced to economists Boulding (1966) and Daly (1977), who argued that the Earth should be regarded as a closed system and that this should be reflected in economic policy. By the 1990s links had been made between the circular economy and product lifetimes (Stahel and Jackson, 1993; Cooper, 1994, 1999). In subsequent discussion, prompted by the European Union's Action Plan for the Circular Economy, the initial focus was on 'closing the loop' (i.e. recyclability), although a need to 'slow the flow' (i.e. longevity) is now recognised (Cooper, *forthcoming*). The transition to a circular economy is understood to demand structural change in the economy, involving lower output in some industry sectors and more in others, but little research on it has been undertaken from the perspective of economics; most journal papers on the circular economy have been written by academics from other disciplines.

Aim, method and structure

The aim of this paper is to review the current state of knowledge on product lifetimes from the perspective of economics. It draws upon the burgeoning literature relating to product longevity from academia, public bodies and policy organisations in order to explore how our understanding of product lifetimes could be informed by economic theory and practice.

The flaws in mainstream economics, some of them identified in this paper, have long been criticised by heterodox economists. The

primary purpose of the paper, however, is to explore the potential value to be gained from engagement with the economics discipline rather than the need to transform it.

The method used was a systematic literature review (Tranfield et al., 2003). Appropriate key words were identified and applied to Google Scholar. For instance, to trace theoretical studies search terms such as 'market structure, product durability' were used. For empirical studies, terms such as 'economic impacts, circular economy' were used. Abstracts were read and grouped according to their theoretical and empirical content.

The next section considers the use of macroeconomic models to explore the economic implications of increased product lifetimes and how they relate to economic policy goals. This is followed by some examples of how microeconomic theory might be applied to product lifetimes.

Product lifetimes and the economy

Recent studies on the potential macroeconomic implications of circular economy strategies, some of which incorporate longer lasting products, have used both product-based analysis and quantitative modelling.

Product-based analysis (alternatively termed accounting modelling) provides insights into the likely costs and benefits of increased material or product circularity in one or more sectors. Such analysis does not, however, incorporate economy feedback processes such as those associated with changing prices. Quantitative modelling, by contrast, enables the effect of changing prices on supply and demand to be taken into account, and, likewise, interactions and spill-overs of policy on sectors and agents other than the ones initially affected. Product life extension activities are not well represented in such models, however, typically being aggregated with other activities (McCarthy et al., 2018).

Product-based analysis

One of the earliest government studies on product longevity used interviews and stock and sales modelling to identify and assess the potential impact on the economy of measures to extend product lifetimes and concluded that, overall, they were 'mixed'. The impact on manufacturing was "broadly negative but limited" (Environmental Resources Management, 2011, p. 18). The impacts on retail and distribution varied, some being negative and relatively deep. By contrast, the impacts on repair, refurbishment and maintenance (and, to a lesser extent, the second-hand market) were positive. Some measures offered substantial benefits to businesses and consumers but lower turnover for retailers and lower VAT receipts for government.

A subsequent report on the circular economy considered reuse and better design to determine whether producing, selling and consuming less material might prove more attractive to businesses and consumers than mass produced goods based on low labour costs and economies of scale (Ellen MacArthur Foundation (2013). The inputs needed to make a new product in a linear economy were compared with those needed in a circular economy. For example, the cost of materials used in reverse-cycle processes were compared with the cost of virgin inputs saved through materials recovery. The potential for net material cost savings in European manufacturing was calculated as up to $630bn annually, equivalent to 3.9% of the EU Gross Domestic Product (GDP).

A third study used a detailed sector-based analysis to estimate the impact of an expanding circular economy on the Netherlands economy as a whole (Bastein et al., 2013). Insights from literature, interviews and a workshop were used to estimate the current value of the circular economy in the metal and electrical sectors and its potential for expansion. The number of new products entering circulation each year was compared with the number repaired, reused and recycled, and a similar comparison was performed for the value of new products and of repaired goods, reused items and recycled material. The value of the circular economy in the two sectors was estimated at €3.3bn and the potential for expansion €573m per year. The impacts on the economy as a whole were then calculated by extrapolating the findings to comparable industry sectors; the study estimated the overall market value presented by circular economy opportunities to be €7.3bn annually, equivalent to 1.4% of GDP.

Quantitative modelling

A second macroeconomic approach is to use economy-wide models. A recent review of the use of such models to explore the macroeconomic consequences of transition to a circular economy identified 24 studies that used either computable general equilibrium models (CGE) or macro-econometrics models (ME) (McCarthy et al., 2018). It noted, however, that although longer lasting products are often identified as a key element of the transition, they are not explicitly represented in such studies because "CGE and ME models are based on representations of economic flows … (and) … include very little stock accounting" (McCarthy et al., 2018, p.27).

The authors concluded that, in principle, longer product lifetimes could be modelled through an exogenous decrease in demand for more robustly designed products, thus lowering total sales revenue - although such products might fetch higher prices, which would reduce or even negate this. Alternatively, the models could assume that increased longevity is captured in the price of products and total sales remains unchanged, in which case the total demand in value terms would be unaffected. The report warned of the current limitations of macroeconomic models: there is, for example, considerable uncertainty over the effects of changes in product lifetimes on consumption and investment, and thus on national income.

Two macroeconomic studies that use input-output models to address product lifetimes merit attention here, although the first only considers 'first order' effects and the second uses a static model; both recommend the use of CGE models to extend their work.

The first study, prepared for a European Parliament committee, developed an analytical framework and set of definitions in order to consider how the benefits and costs of longer product lifetimes would be distributed across society (Montalvo et al., 2016). The five sectors most likely to benefit from (or be affected by) longer product lifetimes were identified - repair, design, (material) science, waste treatment and rental - and, using the EU-28 aggregated input-output table, sectoral and geographical effects of an increase in value-added in these sectors were explored. The report concluded that longer product lifetimes would improve competitiveness in Europe (as a result of an increase in the value added to products), have a positive effect on the European Union's trade balance, and generate low- and medium-skilled jobs.

The second study used input-output models to explore the impact on carbon emissions and employment of measures aimed at decoupling economic growth from resource use in five European countries (Wijkman and Skånberg, 2017). One of its three scenarios involved doubling the life-span of consumer goods, a 25% increase in material efficiency and replacing 50% of virgin materials by secondary materials; the others addressed renewable energy and energy efficiency. The research found that the material efficiency scenario led to the largest increase in employment; it also reduced carbon emissions, though not by as much as the other two scenarios.

Impacts on economic goals

The impact of circular economy strategies on the traditional macroeconomic goals of growth in GDP, low unemployment and a satisfactory balance of trade has been estimated in several studies.

Despite longstanding criticism, economic growth remains a key indicator in public policy. In a linear economy the continual updating of products fuels GDP, whereas in a circular economy the likely shift in economic activity from manufacturing to the service sector (as goods are maintained for longer) has uncertain implications for GDP. There is tension between innovation and product longevity: Fishman et al. (1993, p. 361) warned that "if products are too durable, potential innovators may lack the incentives to invest in the development of a new technology and the economy may stagnate as a result."

Several studies modelling a circular economy transition have addressed economic growth. A study on measures to increase resource productivity concluded that improvements of 2%-2.5% p.a. could be achieved with net positive impacts on GDP but, beyond this rate, added costs would outweigh the benefits (Cambridge Econometrics and Bio Intelligence Service, 2014). Another study concluded that resource productivity could grow by up to 3% p.a., generating a 'primary resource benefit' to Europe's economies of around €1.8 trillion and

leading to an increase in GDP of up to 7% by 2030 (Ellen MacArthur Foundation, 2015).

Transition to a circular economy might increase employment because of the labour-intensive nature of maintenance and repair activities associated with longer product lifetimes, although there could be a negative effect on employment in manufacturing and retailing. Overall, the studies cited above have indicated positive employment effects. The €7.3 billion added value generated by expanding the circular economy in the Netherlands was predicted to generate around 54,000 jobs (Bastein et al., 2013). An improvement of 2% p.a. in resource productivity was expected to create around two million additional jobs in the EU (Cambridge Econometrics and Bio Intelligence Service, 2014). A material efficiency decoupling scenario in five countries suggested employment gains ranging from 50,000 in Finland and Sweden to 300,000 in France (Wijkman and Skånberg, 2017).

Another study, on employment and resource efficiency, explored the impact of 'preparation for reuse' targets for municipal solid waste: 20%-30% for textiles and 35%-45% for furniture. Based on a literature review and an assessment of established practice, it concluded that up to 269,000 jobs in furniture reuse and 30,000 jobs in textiles reuse could be created (European Environmental Bureau (2014). Lastly, a UK study based on an econometric model concluded that fiscal reform such as switching taxes from labour to resource use would create 455,000 jobs (Green Fiscal Commission, 2010).

A few studies have considered the potential effect of increased product longevity on the balance of trade. One concluded that longer product lifetimes would have a positive effect because they would "reduce dependency on non-EU imports to meet European demand" (Montalvo et al., 2016, p. 41). The effect would be greatest for electric and electronic equipment, textiles, transport equipment and furniture, as the proportion of such goods that are imported is relatively high. A Club of Rome study also drew a positive conclusion about the effect of decoupling on the trade balance; it found that a materially efficient strategy would result in a trade surplus improvement equivalent to 1-2% of GDP (Wijkman and Skånberg (2017).

Product lifetimes and markets

This section explores how microeconomic theory could inform understanding of product longevity with reference to market mechanisms and, specifically, market failure. The topics addressed are necessarily selective due to limitations of space; the potential range of topics is substantial.

Market mechanisms

Production and consumption are explained in economics through the concept of markets, where prospective buyers and sellers make decisions that determine the demand for, and supply of, goods and services.

The determinants of demand identified in economic theory include price, tastes and preferences, necessity, the price of other goods (either substitutes or complementary), and the level and distribution of income. Such relationships could be used to explore, for example, the effect of an increase in incomes on the demand for longer lasting products (which are liable to be relatively expensive).

Economics textbooks rarely address product lifetimes and often even fail to distinguish between consumer durables (e.g. vehicles, appliances, furniture), semi-durables (e.g. clothing) and non-durables (e.g. food, energy), even though markets may operate differently in each case. This is significant: as the lifetime of consumer durables is variable (being determined by inherent durability and consumers' disposal decisions) replacement cycles vary, making future demand harder to predict. In addition, demand may be affected by higher transaction costs (because consumer durables are not bought frequently) (Parks, 1974) and second-hand markets (Miller, 1961).

Price is a key economic variable. In the specific case of a durable good, consumers need to know its anticipated lifetime, in addition to its 'point of sale' price, in order to assess the cost of ownership over the period of use.

When addressing tastes and preferences economists typically use ordinal utility (i.e. ranking levels of consumer satisfaction from different products) in order to create indifference curves. This is a rather narrow approach to consumer behaviour compared with theories in marketing, which address factors such as people's values, attitudes,

intention, habits and social norms, and the purchasing context. Such theories have informed studies on consumer behaviour relating to product lifetimes, notably research on user attachment and disposal behaviour (Cooper et al., 2015; Bakker and Mugge, 2017).

Other determinants of demand include the level and distribution of income. In theory, the historic increase in GDP should make longer lasting products more affordable. Indeed, a recent study indicated a trend towards increased product lifetimes (Oguchi and Diago, 2017), although other studies (cited in Bakker et al., 2014 and German Environment Agency, 2017) have identified a decline, at least for electrical and electronic goods. As longer lasting products are liable to be less affordable to poorer households, in particular, the distribution of income is highly significant (Cooper, 1998). Policy measures aimed at product lifetimes, such as minimum quality standards, might disproportionately benefit higher and middle income households (Environmental Resources Management, 2011).

The supply of goods is primarily determined by price in relation to the costs of production, notably raw materials and labour. In industrialised countries the relative cost of different factors of production has led to an excessive use of primary raw materials and a tendency to minimise the use of labour (von Weizsacker and Jesinghaus, 1992; Cooper, 1999), with obvious implications for product lifetimes: as repair and maintenance tends to be labour-intensive, high labour costs make replacement relatively cost-effective.

Another determinant of supply is the profitability of other goods (i.e. substitutes). In the case of consumer durables, the supply of relatively cheap, low quality goods represents an alternative to goods designed for longevity. The supply of longer lasting goods thus depends on their production costs, relative to those of shorter-lived alternatives, and the price premium that consumers are willing to pay.

Markets for consumer durables interact with markets for second-hand items, the supply of which depends on repair costs, people's willingness to bear the risk of breakdown, their evaluation of 'newness', and personal circumstances (Miller, 1961). Although reuse is often advocated in environmental grounds, Thomas (2003) notes a long tradition of economists who concluded that second-hand markets may increase demand for new goods. For example, Scitovsky (1994, p. 37) argued that second-hand markets "stimulate the economy partly by enabling the well-to-do the sooner to replace their worn out or obsolescing durable goods with new ones and thereby increasing the total demand for them." A recent empirical study concluded that only 27% of second-hand purchases displaced the purchase of a new item (WRAP, 2013).

Market failure

Inadequate product lifetimes may arise from different forms of market failure, as described in the following three examples.

First, in the ideal situation of perfect competition buyers need to be fully informed about goods, including their anticipated lifetimes. Consumers need to be able to make choices that will maximise their utility (i.e. satisfaction) if markets are to operate efficiently, and this requires that they know how long consumer durables are intended to last. They cannot assume that price is a reliable indicator of quality: marketing researchers have found the evidence ambiguous (Rao, 2005) and the relationship has attracted little interest from economists (Bowbrick, 1992). Lifespan labels have been advocated by the European Economic and Social Committee (2016) as means to inform consumers.

Consumers' decisions are even harder in second-hand markets. Akerlof (1970) gave the example of used car markets in which sellers have information on the quality of used cars that buyers lack (i.e. information is 'asymmetric'). If buyers are only willing to pay a price reflecting the average quality of the cars offered for sale, a supplier of a good quality used car might choose to keep it rather than sell it. As the average quality of used cars would consequently fall, buyers might become less willing to pay the prevailing price, prompting more sellers to withdraw from the market. Uncertainty about quality has led to a flaw in the market mechanism.

Second, individuals and households may face costs arising from economic transactions for which they are not responsible (i.e. externalities). This is relevant to product lifetimes because the cost of managing waste is

typically not paid directly by the consumers responsible but through collective charges to households. 'Pay as you throw' charges have been proposed to address this. Theoretical studies that have addressed the relationship between product durability and waste management suggest that policies which internalise the costs of waste disposal should result in increased product durability (Runkel, 2003).

Third, competition may not merely be imperfect but constrained by a monopoly or oligopoly situation, in which sellers are able to influence the supply or price of goods. There is a longstanding debate among economists on the relationship between market structure and product durability, stimulated by concern about cartels in certain product sectors (e.g. light bulbs, razor blades) (Avinger, 1981). Its origins have been traced to an article which, noting that "durability is an aspect of products which is exceedingly variable" (Chamberlin, 1953, p. 23), raised the question of how durable producers should make goods in order to maximise their profits, and whether this would be affected by the extent of competition.

In a series of theoretical papers some economists argued that a monopolist chooses an inefficiently low level of durability compared with a producer in a competitive situation (e.g. Martin, 1962; Kleiman and Ophir, 1966; Levhari and Srinivasan, 1969; Schmalensee, 1970), while others refuted this and argued that monopolists exploit their market power through prices rather than product durability (e.g. Swan, 1970). Later papers (Stokey, 1981; Bulow, 1986) used different argumentation to conclude that the earlier papers had, in fact, drawn the correct conclusion, albeit using flawed reasoning (Snelgrove and Saleh, 2016). A review of these earlier papers criticized the use of "simplified models that gave very incomplete pictures of actual durable goods markets" (Waldman, 2003, p. 132) and noted that "most of the literature assumes either monopoly or perfect competition, while clearly most real world markets are either oligopolistic or monopolistically competitive" (Waldman, 2003, p. 150). The author described subsequent advances in microeconomic theory on durability choice and issues associated with new product introductions but concluded that further research is required.

Conclusions

This review of literature relating economics to product lifetimes has found that there is potential for significant insights from the discipline that could inform future, multidisciplinary academic discourse.

Until the emergence of a series of studies on the transition to a circular economy, economists paid little attention to product lifetimes from a macroeconomic perspective. These studies have mostly addressed resource efficiency or decoupling strategies, however; only one has specifically focussed on product lifetimes. Overall, they conclude that the transition to a circular economy would have a positive effect on growth, employment and the balance of trade (BITC, 2018), although product life extension activities are currently not well represented in quantitative models.

Similarly, aside from theoretical studies on durability choice and market structures, there has been little research on product lifetimes from a microeconomic perspective. Even in studies that have addressed topics such as information asymmetry and second-hand markets product longevity has not been the main focus. More research is needed in these areas and others, such as how economies of scale and depreciation rates influence product lifetimes. More generally, while there is an apparent consensus that the circular economy concept is useful, economists need to contribute to greater understanding of the interface between material flows and economic flows.

Finally, all economies are influenced by government policy. Policymakers have an important role to play in the transition to a circular economy. Economic policies to increase product longevity may take the form of green fiscal reform but a wide range of market-based, regulatory and voluntary instruments are available (Cooper, 2010).

References

Akerlof, G.A. (1970). The market for "lemons": quality and the market mechanism. The Quarterly Journal of Economics 84, 488-500.

Avinger, R.L. (1981). Product durability and market structure: some evidence. The Journal of Industrial Economics 29, 357-374.

Bakker, C. and Mugge, R. (eds.). (2017). Product Lifetimes and the Environment (PLATE) Conference Proceedings, 8-10 November. Delft: Delft University of Technology and IOS Press.

Bakker, C., Wang, F., Huisman, J., den Hollander, M. (2014). Products that go round: exploring product life extension through design. Journal of Cleaner Production 69, 10–16.

Bastein,T., Roelofs, E., Rietveld,E., & Hoogendorn, A. (2013). Opportunities for a Circular Economy in the Netherlands, TNO (The Netherland Organisation for Applied Scientific Research). [online]. Retrieved from https://www.tno.nl/media/8551/tno-circular-economy-for-ienm.pdf

Bowbrick, P. (1992). The Economics of Quality, Grades and Brands. Revision of first edition. London: Routledge. (online). Retrieved from: http://www.bowbrick.org.uk/Publications/Quality%20Grades%20Brands%202011.pdf

Boulding, K.E. (1966). The Economics of the Coming Spaceship Earth. In: H. Jarrett (ed.) Environmental Quality in a Growing Economy, pp. 3-14. Baltimore, MD: Resources for the Future/Johns Hopkins University Press.

Bulow, J. (1986). An economic theory of planned obsolescence. Quarterly Journal of Economics 101, 729-749.

Business in the Community (BITC). (2018). Smart Growth: the economic case for the circular economy. Report by WRAP for BITC. [online]. Retrieved from https://www.bitc.org.uk/resources-training/resources/research/smart-growth-economic-case-circular-economy

Cambridge Econometrics and Bio Intelligence Service (2014). Study on modelling of the economic and environmental impacts of raw material consumption. Brussels: European Commission. (online). Retrieved from http://ec.europa.eu/environment/enveco/resource_efficiency/pdf/RMC.pdf

Chamberlin, E.H. (1953). The product as an economic variable. Quarterly Journal of Economics 67(1), 1–29.

Cooper, T. (1994). Beyond Recycling: The longer life option. London: New Economics Foundation.

Cooper, T. (1998). Poor people, poor products? The Home Economist 17(4), 21-24.

Cooper, T. (1999). Creating an economic infrastructure for sustainable product design. The Journal of Sustainable Product Design, 7-15.

Cooper, T. (2010). Policies for Longevity. In: T. Cooper (ed.), Longer Lasting Products: Alternatives to the throwaway society, pp. 215–240. Abingdon: Routledge.

Cooper, T. (forthcoming). Slower Cycles: An essential characteristic of the circular economy. In: S. Eisenriegler (ed.). The Circular Economy in the European Union - An Interim Review. Berlin: Springer.

Cooper, T., Braithwaite, N., Moreno, M. and Salvia, G. (eds). (2015). Product Lifetimes and the Environment (PLATE) Conference Proceedings, 17-19 June. Nottingham: CADBE, Nottingham Trent University.

Daly, H. (1977). Steady-State Economics. San Francisco: W.H.Freeman.

Ellen MacArthur Foundation. (2013). Towards the Circular Economy: Economic and business rationale for an accelerated transition. Volume 1. [online]. Retrieved from https://www.ellenmacarthurfoundation.org/publications/towards-the-circular-economy-vol-1-an-economic-and-business-rationale-for-an-accelerated-transition

Ellen MacArthur Foundation. (2015). Growth Within: A circular economy vision for a competitive Europe. [online]. Retrieved from https://www.ellenmacarthurfoundation.org/assets/downloads/publications/EllenMacArthurFoundation_Growth-Within_July15.pdf

Environmental Resources Management. (2011). Longer Product Lifetimes. Summary Report. [online]. Retrieved from http://randd.defra.gov.uk/Document.aspx?Document=SummaryReport.pdf

European Economic and Social Committee (EESC). (2016). The Influence of Lifespan Labelling on Consumers. Report by SIRCOME, University of South Brittany and University of South Bohemia. (online). Retrieved from: http://www.eesc.europa.eu/?i=portal.en.publications.38844

European Environmental Bureau (2014). Advancing Resource Efficiency in Europe. Brussels: EEB. (online). Retrieved from https://eeb.org/library/advancing-resource-efficiency-in-europe/

Fishman, A., Gandal, N., & Shy, O. (1993). Planned obsolescence as an engine of technological progress. Journal of Industrial Economics XLI, 361-370.

German Environment Agency. (2017). Strategies against Obsolescence: Ensuring a minimum product lifetime and improving product service life as well as consumer information. (online). Retrieved from: https://www.umweltbundesamt.de/en/publikationen/strategies-against-obsolescence-ensuring-a-minimum

Green Fiscal Commission. (2010). A Major Green Fiscal Reform for the UK: Results for the economy, employment and the environment. [online]. Retrieved from http://www.greenfiscalcommission.org.uk/images/uploads/gfcBriefing5_PDF_isbn_v5.pdf

Kleiman, E. and Ophir, T. (1966). The durability of durable goods. Review of Economic Studies 33(2), 165-178.

Levhari, D. and Srinivasan, T. N. (1969). Durability of consumption goods: competition versus monopoly. American Economic Review 59, 102-107.

Martin, D. (1962). Monopoly power and the durability of durable goods. Southern Economic Journal 28(3), 271–277.

McCarthy, A., Dellink, R. and Bibas, R. (2018). The Macroeconomics of the Circular Economy Transition, OECD Environment Working Papers, No. 130. Paris: OECD Publishing. (online). Retrieved from https://www.oecd-ilibrary.org/environment/the-macroeconomics-of-the-circular-economy-transition_af983f9a-en

Miller, H.L, Jr. (1961). On the theory of consumer durables. Southern Economic Journal 27(4), 298-304.

Montalvo, C., Peck, D. and Rietveld, E. (2016). A Longer Lifetime for Products: Benefits for consumers and companies. Study for IMCO Committee, European Parliament. (online). Retrieved from http://www.europarl.europa.eu/RegData/etudes/STUD/2016/579000/IPOL_STU(2016)579000_EN.pdf

Oguchi M. and Diago I. (2017). Measuring the Historical Change in the Actual Lifetimes of Consumer Durables. In: C.A. Bakker and R. Mugge (eds.). Product Lifetimes and the Environment (PLATE) Conference Proceedings, 8-10 November. Delft: Delft University of Technology and IOS Press.

Parks, R. (1974). The demand and supply of durable goods and durability. American Economic Review 64(1), 37-55.

Rao, A.R. (2005). The quality of price as a quality cue, Journal of Marketing Research XLII, 401–405.

Runkel, M. (2003). Product durability and extended producer responsibility in solid waste management. Environmental and Resource Economics 24, 161-182.

Schmalensee, R. (1970). Regulation and the durability of goods. Bell Journal of Economics and Management Science 1, 54-64.

Scitovsky, T. (1994). Towards a theory of second-hand markets. Kyklos 47(1), 33–51.

Snelgrove, K.B. & Saleh, J.H. (2016). Toward a new spacecraft optimal design lifetime? Impact of marginal cost of durability and reduced launch price. Acta Astronautica 127, 271-282

Stahel, W.R. and Jackson, T. (1993). Optimal Utilisation and Durability - Towards a New Definition of the Service Economy. In: T. Jackson (ed.) Clean Production Strategies, pp. 261–291. Boca Raton, FL: Lewis Publishers.

Stokey, N.L. (1981). Rational expectations and durable goods pricing. Bell Journal of Economics 12, 112-128.

Swan, P.L. (1970). Durability of consumption goods. American Economic Review 60, 884-894.

Thomas, V.M. (2003). Demand and dematerialization impacts of second-hand markets: Reuse or more use? Journal of Industrial Ecology 7(2), 65-78.

Tranfield, D., Denyer, D and Smart, P. (2003). Towards a methodology for developing evidence-informed management knowledge by means of systematic review. British Journal of Management 14, 207-222.

Waldman, M. (2003). Durable goods theory for real world markets. Journal of Economic Perspective 17, 131-154.

von Weizsäcker, E.U. and Jesinghaus, J. (1992). Ecological Tax Reform. London: Zed.

Wijkman, A. and Skånberg, K. (2017). The Circular Economy and Benefits for Society. Report for the Club of Rome. [online]. Retrieved from https://www.clubofrome.org/wp-content/uploads/2016/03/The-Circular-Economy-and-Benefits-for-Society.pdf

WRAP (Waste and Resources Action Programme). (2013). Study into Consumer Second-Hand Shopping Behaviour to Identify the Re-Use Displacement Effect. (online). Retrieved from: http://www.wrap.org.uk/content/study-consumer-second-hand-shopping-identify-re-use-behaviour-0