IRPET
14 July 2022

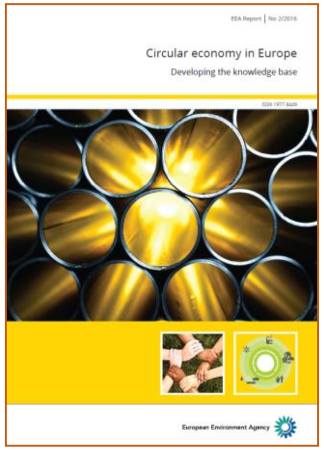
Circular economy transition: Policies, markets, innovation

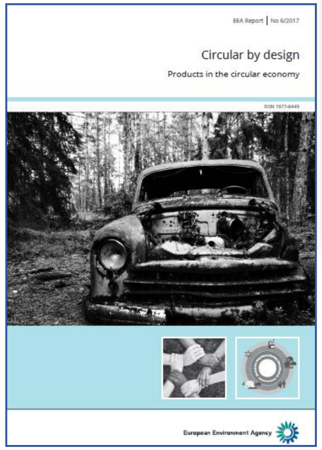
Roberto Zoboli
Università Cattolica del S. Cuore, Milan
Faculty of Political and Social Sciences

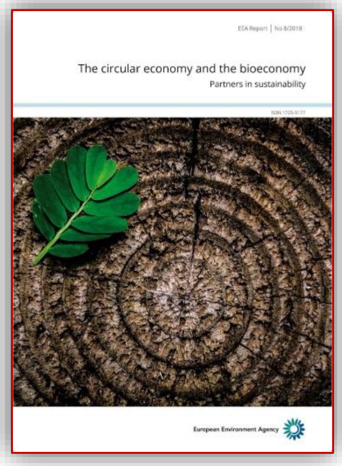
Research at:

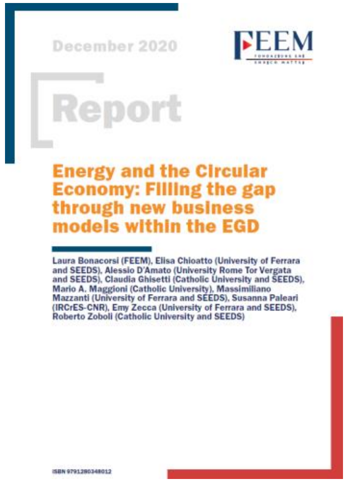
- **SEEDS – Sustainability, Environmental Economics and Dynamics Studies:** Since 2013; From 5 to 8 to 12 universities; 40 environmental and innovation economists http://www.sustainability-seeds.org/
- **IRCrES-CNR: Institute of Research on Sustainable Economic Growth, National Research Council:** Economic research, multidisciplinary https://www.ircres.cnr.it/index.php/it/
- **EEA – ETCs:** European Topic Centres of EEA – European Environment Agency; Since 2001, now ***ETC CE – European Topic Centre on Circular Economy and Resource Use,*** *2022-2026 https://www.eionet.europa.eu/etcs/etc-ce/consortium*
- **ASA- Graduate School on the Environment, Catholic University:** since 2008, multidisciplinary https://asa.unicatt.it/

EEA’s CE reports, 2016, 2017, 2018
http://www.eea.europa.eu/publications/circular-economy-in-europe
https://www.eea.europa.eu/publications/circular-by-design
https://www.eea.europa.eu/publications/circular-economy-and-bioeconomy









FEEM reports on CE, 2019 and 2020
https://www.feem.it/it/pubblicazioni/reports/towards-an-innovation-intensive-circular-economy-integrating-research-industry-e-policies/
https://www.feem.it/publications/energy-and-the-circular-economy-filling-the-gap-through-new-business-models-within-the-egd/

Outline

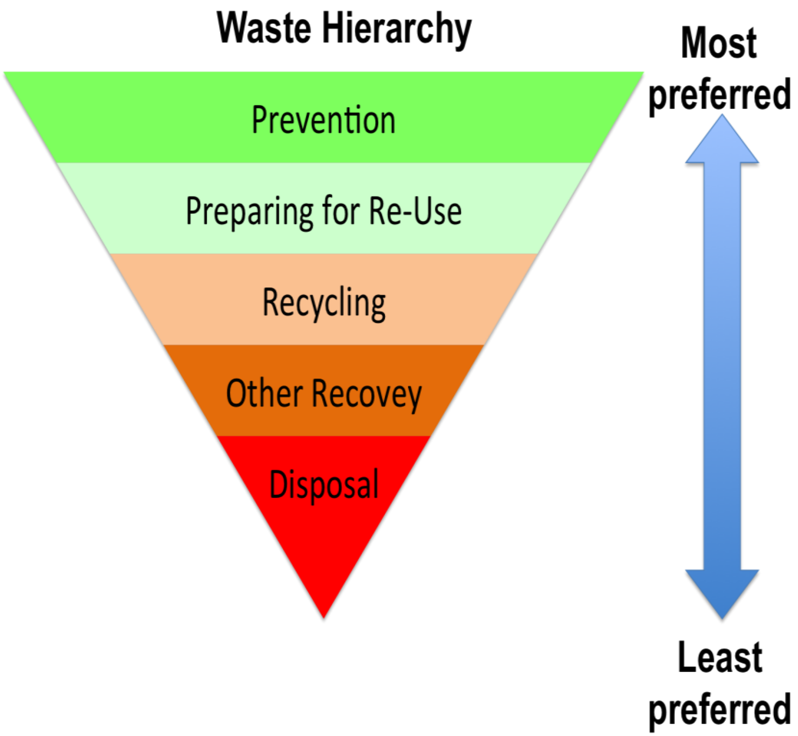
- **CE: A substitution economy?**
- **Drivers: Resource prices Vs Policies**
- **Policy issues 1: Plastics**
- **Policy issues 2: RES and bioresources**
- **Policy issues 3: Secondary Raw Materials markets**
- **Innovation and the CE**

Scope

- *EU level*
- *No ‘measures’ and ‘indicators’*
- *Not so much ‘circular business models’*

CE: A substitution economy?

CE vision already in the EU 'waste hierarchy', 1970s



1975, Waste Framework Directive (1975/442/EEC) introduced the 'waste hierarchy' (Art. 3)

The Ladder of Lansink

The concept of Ellen Mac Arthur Foundation

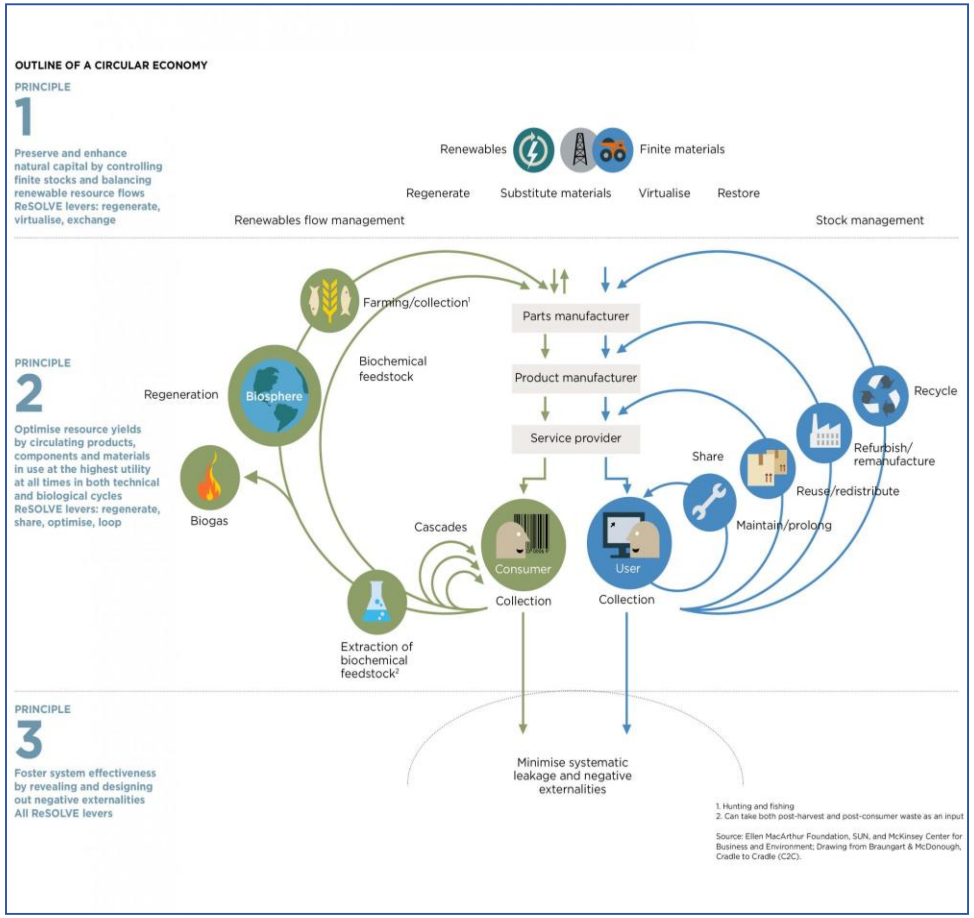
https://www.ellenmacarthurfoundation.org/circular-economy/oundation

'Schools Of Thought'

The circular economy concept has deep-rooted origins and cannot be traced back to one single date or author.

The generic concept has been refined and developed by the following schools of thought:

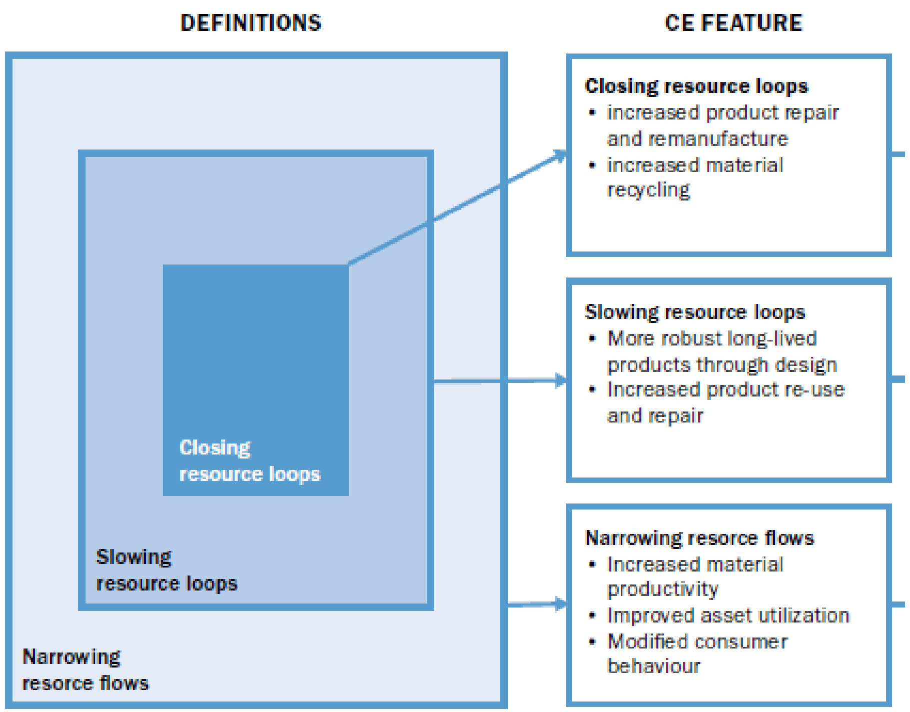
- 1 Cradle to Cradle
- 2 Performance Economy
- 3 Biomimicry
- 4 Industrial Ecology
- 5 Natural Capitalism
- 6 Blue Economy
- 7 Regenerative Design



A useful vision

OECD, THE MACROECONOMICS OF THE CIRCULAR ECONOMY TRANSITION: A CRITICAL REVIEW OF MODELLING APPROACHES, ENV/EPOC/WPRPW/WPIEEP(2017)1/FINAL, 27 October 2017
after Bochen et al. Bocken, N.M.P., de Pauw I., Bakker C. and van der Grinten B., 2016

Figure 1.2. Definitions, features, and effects of the Circular Economy



Source: OECD, 2017.

Closing the resource loops The first level is the (increasing) 'closure of the use loops' of resources (waste and materials) through the (increasing) degree of material **recycling** and **energy recovery** of waste, the increase of materials and products **reuse**, also after **'re-manufacturing'** of complex products or their parts (e.g. in the automotive sector).

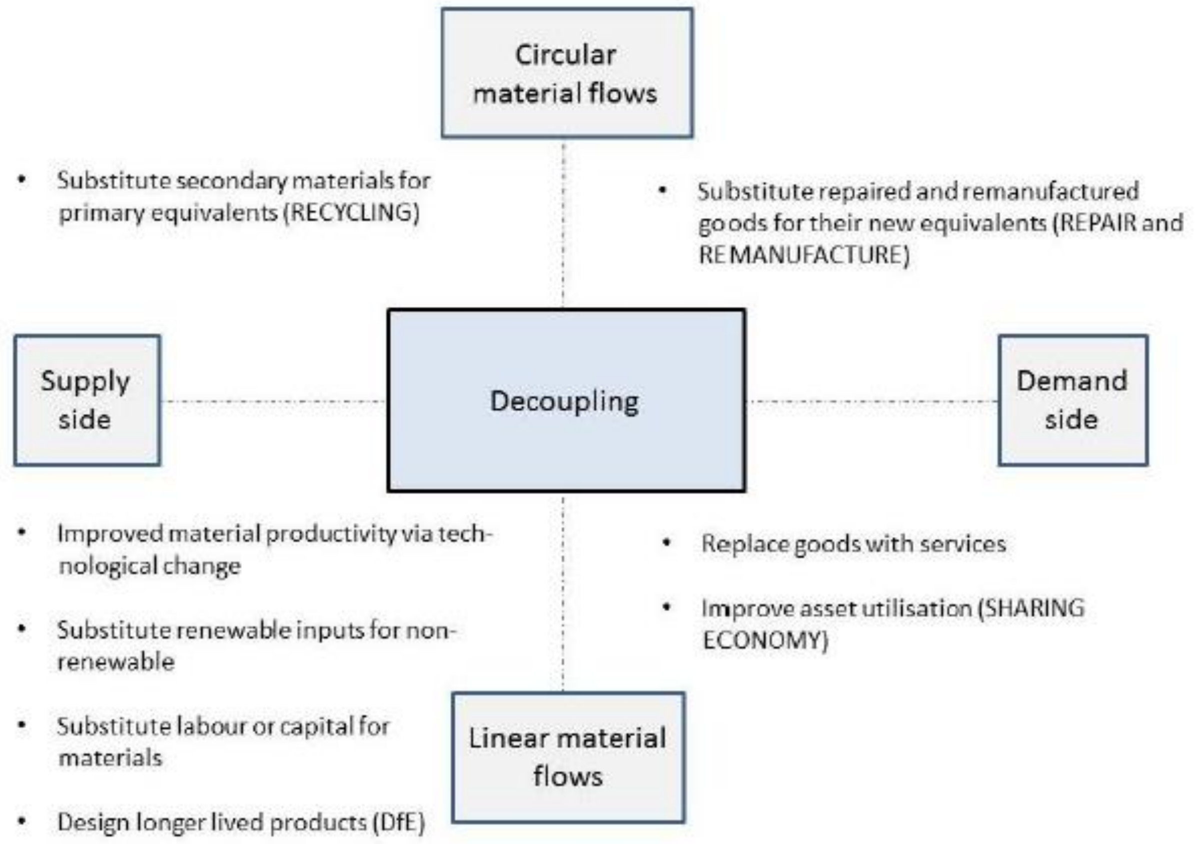
Slowing down resource loops The second level of circularity is about 'slowing down' the use-loops of resources (materials), and it is mainly about the **useful life of products**. This level of CE is at the boundaries of, or even involves, the **'sharing and renting economy'** and similar organizational innovations that can **intensify the use** of goods/capitals and give them a longer life.

Narrowing resource flow The third level of the CE is the 'narrowing' of resource flows through a **higher efficiency of resource use, which can be based on innovation and behavioral change**. It may imply again a more intensive use of goods and capitals (sharing, longer life) and less dissipative consumer choices on materials, energy, and final goods use.

Decoupling and efficiency

OECD, THE MACROECONOMICS OF THE CIRCULAR ECONOMY TRANSITION: A CRITICAL REVIEW OF MODELLING APPROACHES, ENV/EPOC/WPRPW/WPIEEP(2017)1/FINAL, 27 October 2017

Figure 2. Decoupling mechanisms: material circularity vs material efficiency in production vs consumption



Note: Technological change can also facilitate more circular material flows when it results in improved secondary production technologies

Key point: Is CE a substitution economy?

- Weak **net** economic results at the system level
- **Substitition** effects can prevail
- **Environmental** effects can dominate

Oltre a non essere di grandi dimensioni, tali cifre sono da prendere con cautela poiché, secondo il rapporto OCSE per il G7, sono necessari più robusti strumenti modellistici per avere stime quantitative affidabili. Infatti, nell'esaminare i risultati dei macro modelli che contengono elementi di economia circolare, OCSE[36] sottolinea innanzitutto come la rappresentazione della circolarità e degli effetti netti di sistema sia piuttosto debole nei modelli disponibili, anche quelli con strutture input-output o multi-settoriali dettagliate. Conclude inoltre che, sulla base di tale modellistica, vi possono essere effetti macroeconomici appena positivi o insignificanti, e la transizione all'economia circolare può avere conseguenze almeno non negative per la crescita e l'occupazione. La ragione di un basso risultato aggregato è che l'economia circolare prevede una ricomposizione dei settori rendendo, in generale, meno competitivi quelli a uso intensivo di risorse naturali e materiali primari, mentre i settori legati a riciclo, ri-manifattura e riparazione potranno godere di nuovi vantaggi competitivi.

Zoboli R., 2018, L'economia circolare per riusare anche i saperi?, in Paolazzi L, Gargiulo T., Sylos Labini M. (a cura di), *Le sostenibili carte dell'Italia*, Marsilio, Venezia, pp. 139-166.

The Annals of Regional Science
https://doi.org/10.1007/s00168-021-01079-6

SPECIAL ISSUE PAPER

Check for updates

Macroeconomic and environmental consequences of circular economy measures in a small open economy

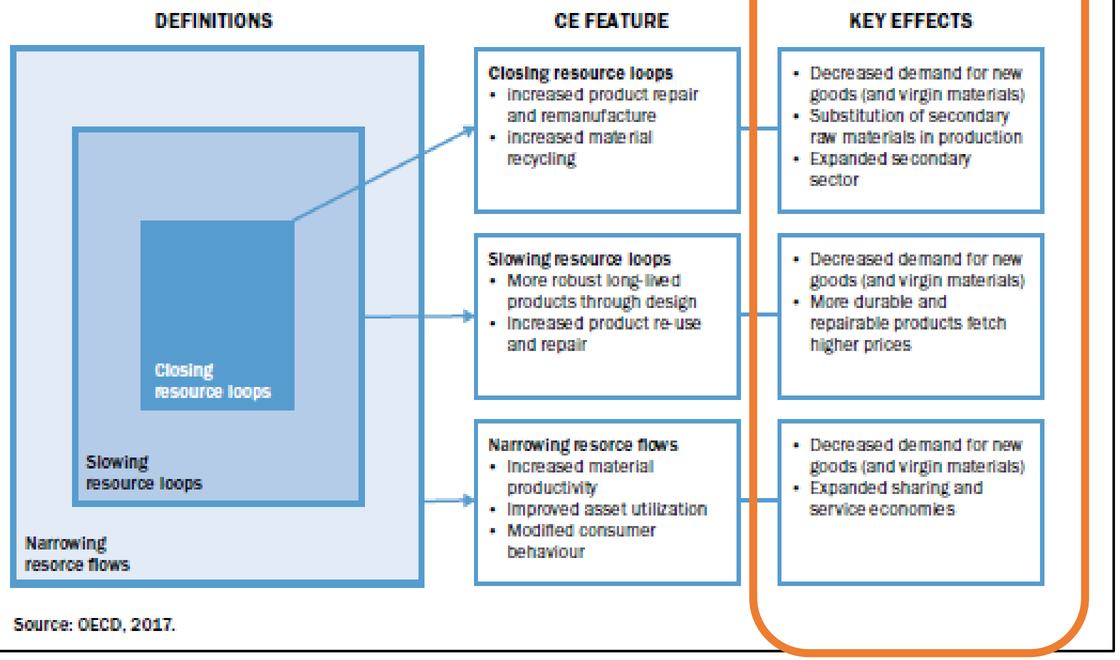
J. Brusselaers[1,2] · K. Breemersch[3] · T. Geerken[2] · M. Christis[2] · B. Lahcen[2,3] · Y. Dams[2]

Received: 2 January 2021 / Accepted: 15 September 2021

Abstract
This paper investigates the economy-wide impact of the uptake of circular economy (CE) measures for the small open economy (SOE) of Belgium, in particular the impact of fiscal policies in support of lifetime extension through repair activities of household appliances. The impact assessment is completed by means of a computable general equilibrium model as this allows quantification of both the direct and indirect economic and environmental impact of simulated shocks. The results show that different fiscal policy types can steer an economy into a more circular direction. However, depending on the policy type, the impact on the SOE's macroeconomic structure and level of circularity differs. Furthermore, common claims attributed to a CE (e.g. local job creation or decreased import dependence) can be, but are not always, valid. Hence, policy-makers must prioritize their most important macroeconomic goals and opt for an according fiscal policy. Finally, this paper finds that the CO_2 equivalent emissions calculated from a production (or territorial) perspective increase, while they decrease from a consumption perspective. This is explained by the substitution of international activities by local circular activities. This comparative analysis advocates for the consumption approach to assess the CE's impact on CO_2 equivalent emissions.

JEL Classification C68 · Q58 · H20

Figure 1.2. Definitions, features, and effects of the Circular Economy

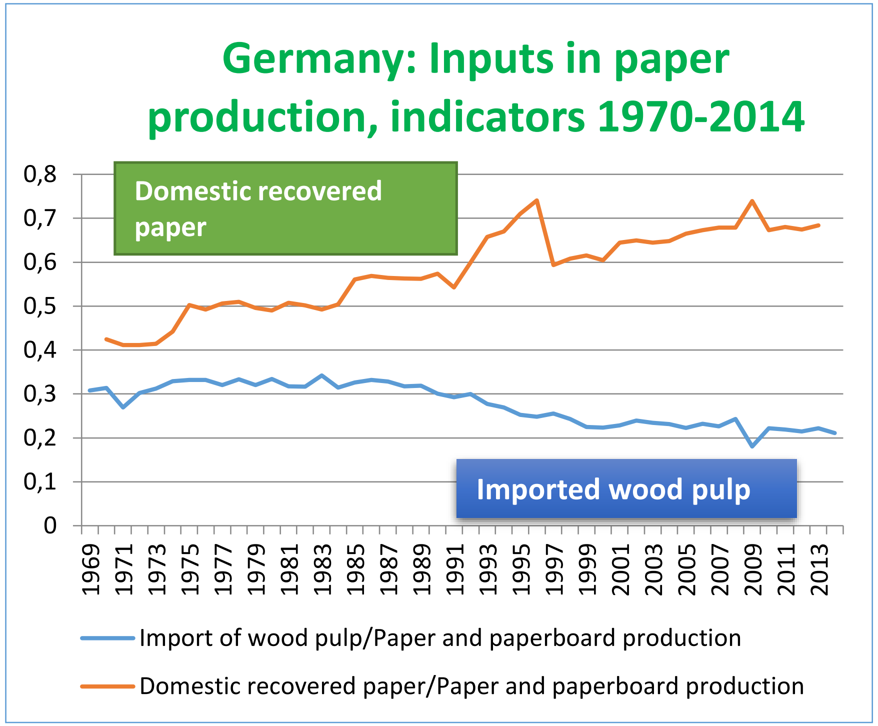


Source: OECD, 2017.

International substitution spillovers
‘Inward-looking’ (domestic) value chains

Circular (secondary) value chains are largely ‘domestic’

- Substitution at the expenses of foreign producers, redistribution of VA and employment
  - Key areas of trade benefits, e.g. critical metals from WEEE
- More domestic production = environmental pressures more domestic (but lower international footprint !)



Resources, Conservation & Recycling 171 (2021) 105621
Contents lists available at ScienceDirect
Resources, Conservation & Recycling
journal homepage: www.elsevier.com/locate/resconrec

Full length article

Circular economy-induced global employment shifts in apparel value chains: Job reduction in apparel production activities, job growth in reuse and recycling activities

Lars Repp *, Marko Hekkert, Julian Kirchherr

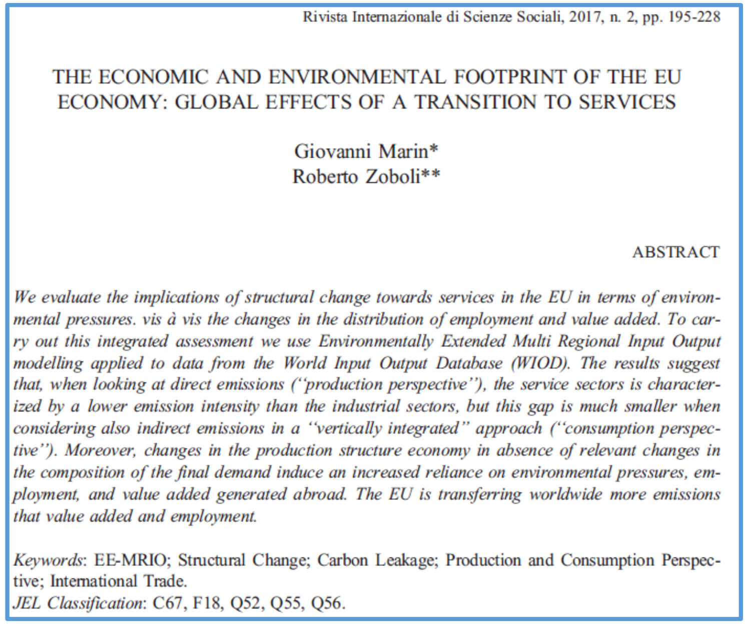
Copernicus Institute of Sustainable Development, Utrecht University, Princetonlaan 8a, Utrecht 3584 CB, The Netherlands

ARTICLE INFO

Keywords:
Circular economy
Social sustainability
Circular fashion
Global employment effects
Clothing industry
Social impacts

ABSTRACT

There is no evidence-based discussion on the intended and unintended global social impacts, such as changes in employment, of the European Union's (EU) transition towards the Circular Economy (CE). Consequently, its ethical implications are nebulous. Therefore, this paper assesses CE-induced global employment shifts using the example of the apparel value chains of apparel imported to the EU from the top five exporting countries: China, Bangladesh, India, Turkey and Cambodia. The discussion of the results is based on the ethical framework for global transformative change that applies justice considerations on sustainability transitions. This paper is the first sector-specific quantitative study on the employment effects of the EU transition on a global scale, including ethical dimensions of those effects, as far as we are aware. Overall, this paper contributes to the broader discussion of CE-induced social effects of sustainability transitions. Its results indicate that employment could significantly decrease in low- to upper-middle-income countries outside the EU, in particular in labour-intense apparel production. Employment could increase in less-labour intense downstream reuse and recycling activities in the EU and second-hand retail in- and outside the EU. From an ethical perspective, the benefits and disadvantages of the circular transition seem to be unevenly distributed, with the main adverse effects to be carried by non-EU stakeholders.



Rivista Internazionale di Scienze Sociali, 2017, n. 2, pp. 195-228

THE ECONOMIC AND ENVIRONMENTAL FOOTPRINT OF THE EU ECONOMY: GLOBAL EFFECTS OF A TRANSITION TO SERVICES

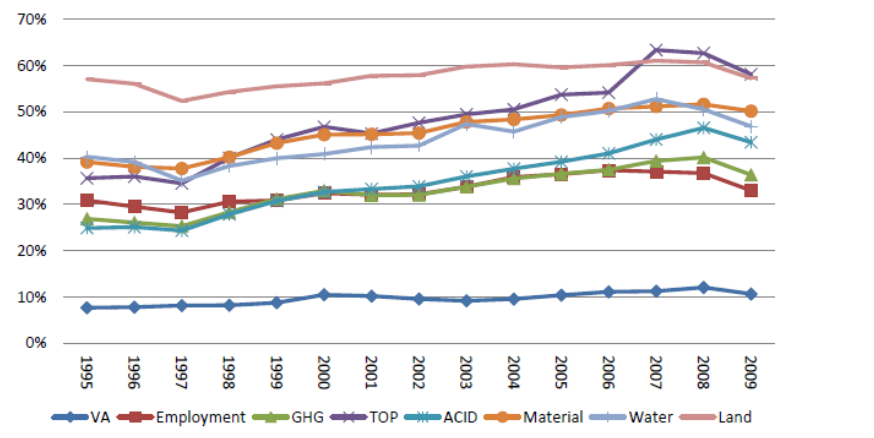
Giovanni Marin*
Roberto Zoboli**

ABSTRACT

We evaluate the implications of structural change towards services in the EU in terms of environmental pressures. vis à vis the changes in the distribution of employment and value added. To carry out this integrated assessment we use Environmentally Extended Multi Regional Input Output modelling applied to data from the World Input Output Database (WIOD). The results suggest that, when looking at direct emissions (“production perspective”), the service sectors is characterized by a lower emission intensity than the industrial sectors, but this gap is much smaller when considering also indirect emissions in a “vertically integrated” approach (“consumption perspective”). Moreover, changes in the production structure economy in absence of relevant changes in the composition of the final demand induce an increased reliance on environmental pressures, employment, and value added generated abroad. The EU is transferring worldwide more emissions that value added and employment.

Keywords: EE-MRIO; Structural Change; Carbon Leakage; Production and Consumption Perspective; International Trade.
JEL Classification: C67, F18, Q52, Q55, Q56.

Figure 1 – Share of environmental pressures and economic activity occurred out of the EU27 to satisfy the final demand of EU27



Source: own elaboration based on WIOD database

Drivers: Prices Vs Policies

Price signals do matter

ENVIRONMENTAL RESEARCH
LETTERS

TOPICAL REVIEW

Induced innovation in energy technologies and systems: a review of evidence and potential implications for CO_2 mitigation

Michael Grubb[1], Paul Drummond[1], Alexandra Poncia[1], Will McDowall[1], David Popp[2,3], Sascha Samadi[4], Cristina Penasco[5], Kenneth T Gillingham[3,6], Sjak Smulders[7], Matthieu Glachant[8], Gavin Hassall[9], Emi Mizuno[10], Edward S Rubin[11], Antoine Dechezleprêtre[12] and Giulia Pavan[13]

1 UCL (University College London), Institute for Sustainable Resources, London, United Kingdom
2 Syracuse University, Maxwell School, Syracuse, NY, United States of America
3 NBER, Cambridge, MA, United States of America
4 Wuppertal Institute for Climate, Environment and Energy, Wuppertal, Germany
5 Department of Politics and International Studies (POLIS) and Centre for Environment, Energy and Natural Resources Governance (C-EENRG), Department of Land Economy, University of Cambridge, Cambridge, United Kingdom
6 Yale University, Yale School of the Environment, Newhaven, CT, United States of America
7 Tilburg University, Tilburg, The Netherlands
8 MINES Paris Tech, PSL University, Paris, France
9 Warwick University, Coventry, United Kingdom
10 Sustainable Energy for ALL, Vienna, Austria
11 Carnegie Mellon University, Pittsburgh, PA, United States of America
12 Grantham Research Institute on Climate Change and the Environment, London School of Economics, London, United Kingdom
13 Compass Lexecon, Madrid, Spain

E-mail: m.grubb@ucl.ac.uk

Keywords: energy innovation, endogenous technological change, learning by doing, induced innovation, CO_2 mitigation costs, innovation policy, directed technological change

Abstract
We conduct a systematic and interdisciplinary review of empirical literature assessing evidence on induced innovation in energy and related technologies. We explore links between demand-drivers (both market-wide and targeted); indicators of innovation (principally, patents); and outcomes (cost reduction, efficiency, and multi-sector/macro consequences). We build on existing reviews in different fields and assess over 200 papers containing original data analysis. Papers linking drivers to patents, and indicators of cumulative capacity to cost reductions (experience curves), dominate the literature. The former does not directly link patents to outcomes; the latter does not directly test for the causal impact of on cost reductions. Diverse other literatures provide additional evidence concerning the links between deployment, innovation activities, and outcomes. We derive three main conclusions. (a) Demand-pull forces enhance patenting; econometric studies find positive impacts in industry, electricity and transport sectors in all but a few specific cases. This applies to all drivers—general energy prices, carbon prices, and targeted interventions that build markets. (b) Technology costs decline with cumulative investment for almost every technology studied across all time periods, when controlled for other factors. Numerous lines of evidence point to dominant causality from at-scale deployment (prior to self-sustaining diffusion) to cost reduction in this relationship. (c) Overall innovation is cumulative, multi-faceted, and self-reinforcing in its direction (path-dependent). We conclude with brief observations on implications for modelling and policy. In interpreting these results, we suggest distinguishing the economics of active deployment, from more passive diffusion processes, and draw the following implications. There is a role for policy diversity and experimentation, with evaluation of potential gains from innovation in the broadest sense. Consequently, endogenising innovation in large-scale models is important

Global Environmental Change 22 (2012) 407–417

Contents lists available at SciVerse ScienceDirect

Global Environmental Change

journal homepage: www.elsevier.com/locate/gloenvcha

Oil prices and energy technology innovation: An empirical analysis☆

Andrew Cheon, Johannes Urpelainen*

Department of Political Science, Columbia University, 420 West 118th Street, 7th Floor, International Affairs Building, New York, NY 10027 USA

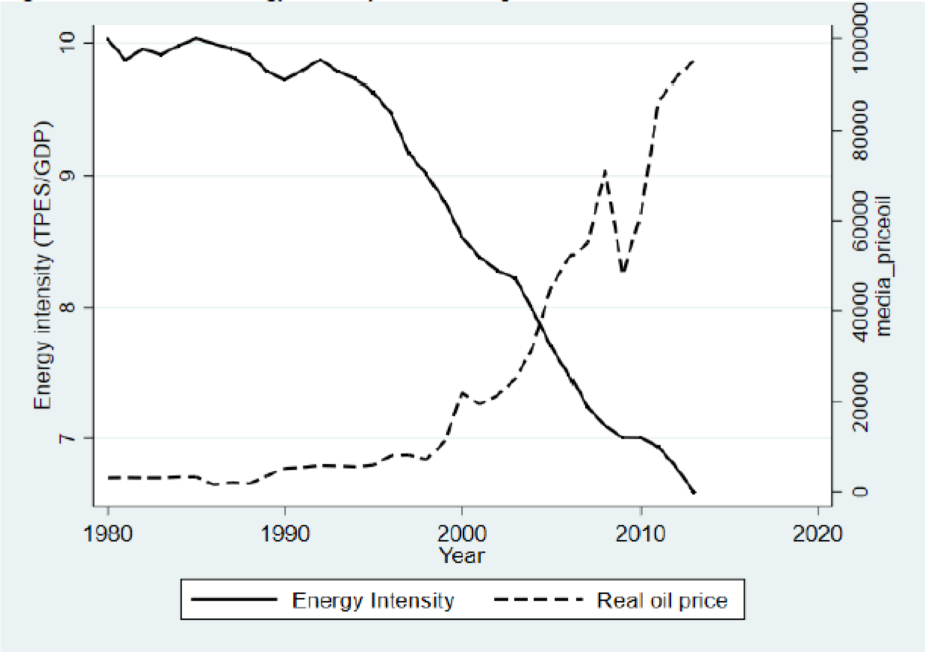
ARTICLE INFO

Article history:
Received 7 September 2011
Received in revised form 8 December 2011
Accepted 17 December 2011
Available online 1 February 2012

ABSTRACT

To achieve environmental sustainability and reduce their vulnerability to oil shocks, countries can develop new energy technologies. Technological advances reduce the cost of structural changes in the energy economy, and thus also increase the political feasibility of such changes. But what explains international variation in the form and quality of energy technology innovation? We build on previous theories and offer an integrated account: increasing oil prices reinforce existing sectoral innovation systems, both politically and economically, thus allowing public policymakers and private entrepreneurs to profitably invest in new energy technologies. We test this theoretical argument against data on public R&D expenditures and patents in the domain of renewable energy technology for industrialized countries from 1989 to 2007. We find strong support for the interactive hypothesis. Thus, we contribute to literatures on (i) domestic responses to international shocks, (ii) environmental sustainability and energy security, and (iii) the political economy of technology innovation.

Figure 1. Evolution of energy intensity and real oil price



Energy Prices and Induced Technological Progress

Surender Kumar
TERI University, New Delhi, India

Abstract

This study measures energy price induced technological change using directional distance function for a panel data of 55 countries over the period 1974 to 2000. The parameter estimates of directional distance function reveal the absence of neutral exogenous innovations and the presence of biased innovations either it is exogenous or energy price induced. We observe larger energy price induced technological change effects in developed countries in comparison to developing countries in the periods after first (1974), and second (1980) world oil crisis that caused substantial energy price increases. These findings concur with data that show most RDoccurs in high-income countries, particularly the US and Japan.

SEEDS
Sustainability Environmental Economics and Dynamics Studies

Working Paper Se

Does energy price affect energy efficiency? Cross-country panel evidence

by

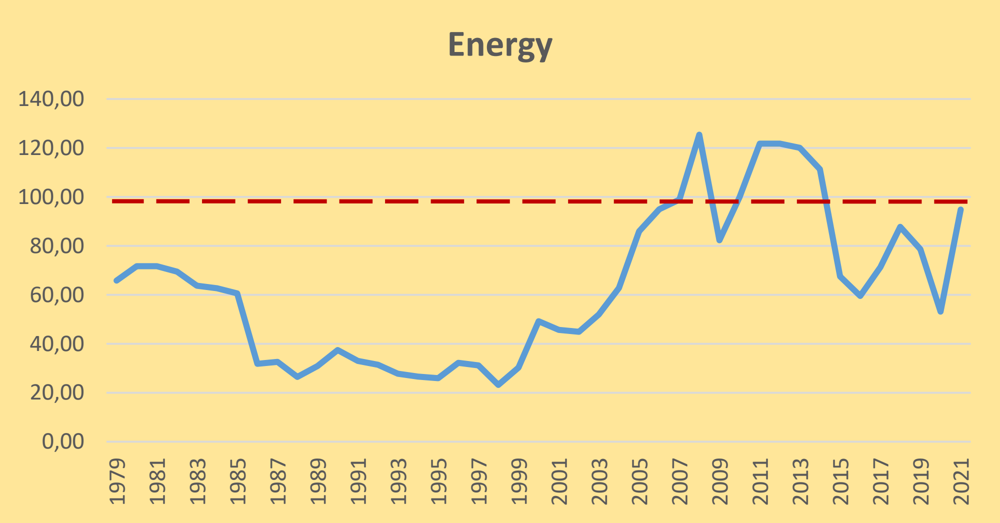
Roberto Antonietti, Fulvio Fontini

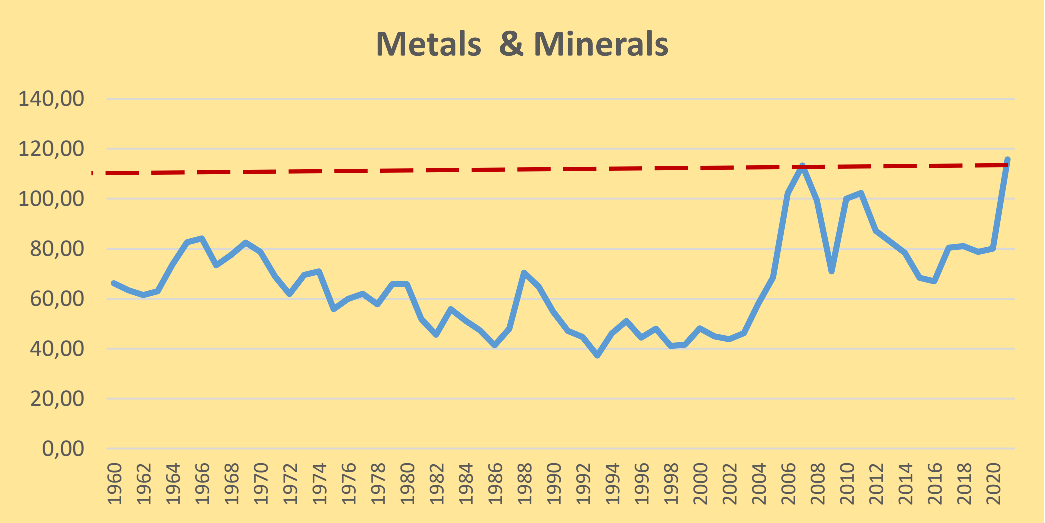
Hassler J., Krusell P., Olovsson C., 2021, Directed Technical Change as a Response to Natural Resource Scarcity, Journal of Political Economy, volume 129, number 11, November 2021.
Abstract: We develop a quantitative macroeconomic theory of input-saving technical change to analyze how markets economize on scarce natural resources, with an application to fossil fuel. We find that aggregate US data call for a very low short-run substitution elasticity between energy and the capital/labor inputs. **Our estimates imply that energy-saving technical change took off when the oil shocks hit in the 1970s.** This response implies significant substitutability with the other inputs in the long run: even under ever-rising energy prices, long-run consumption growth is still possible, along with a modest factor share of energy.
.

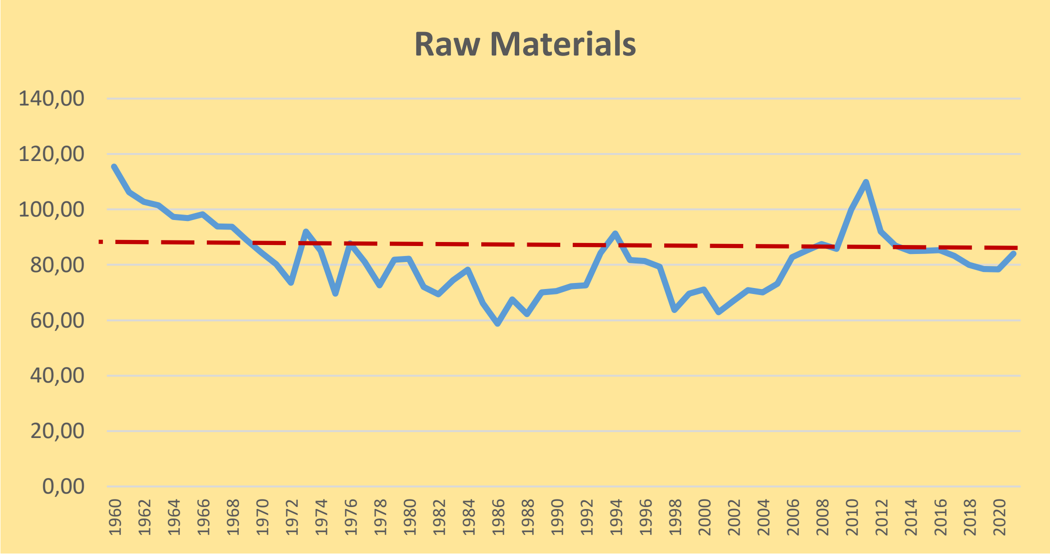
Weak signals from nat resource prices

(World Bank, Indexes of real 2010 prices, 1960/1979-2021)

2021 Real prices at levels of decades ago



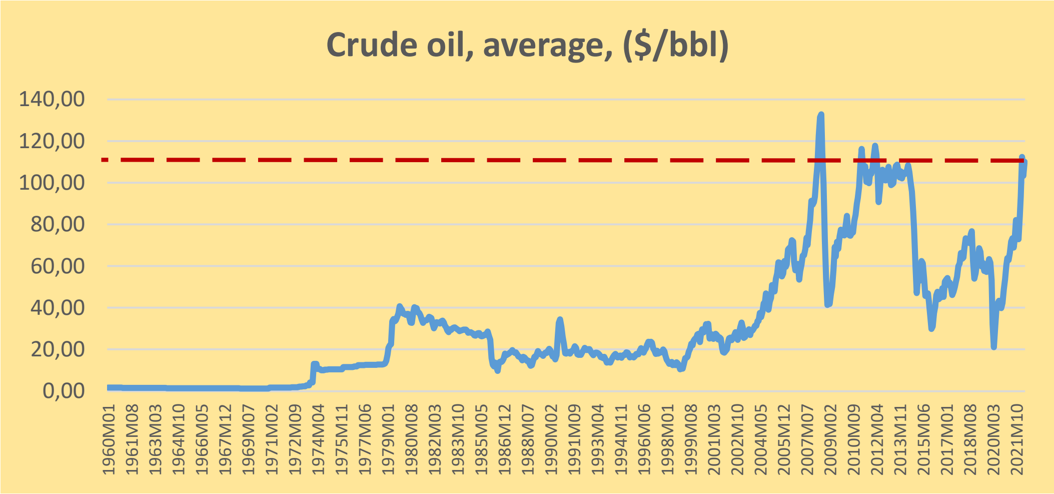


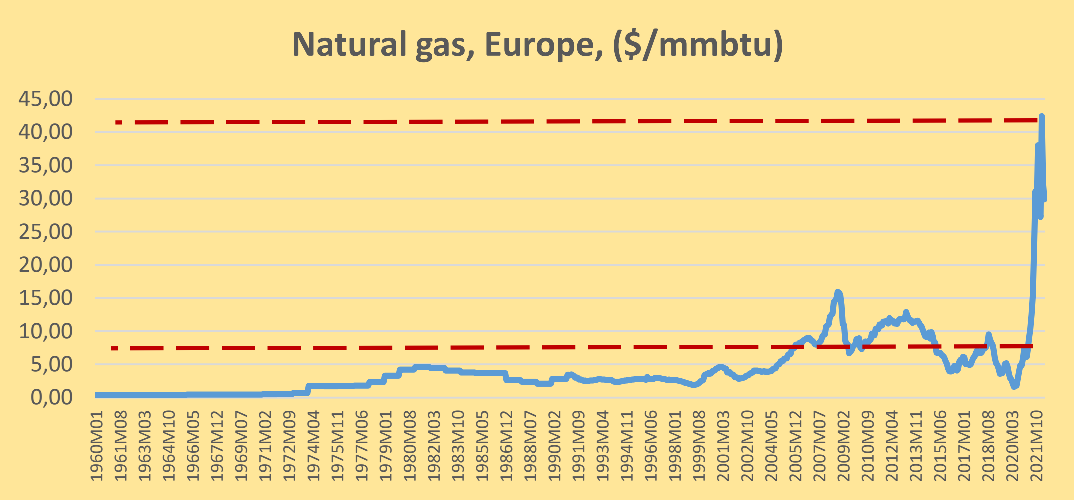


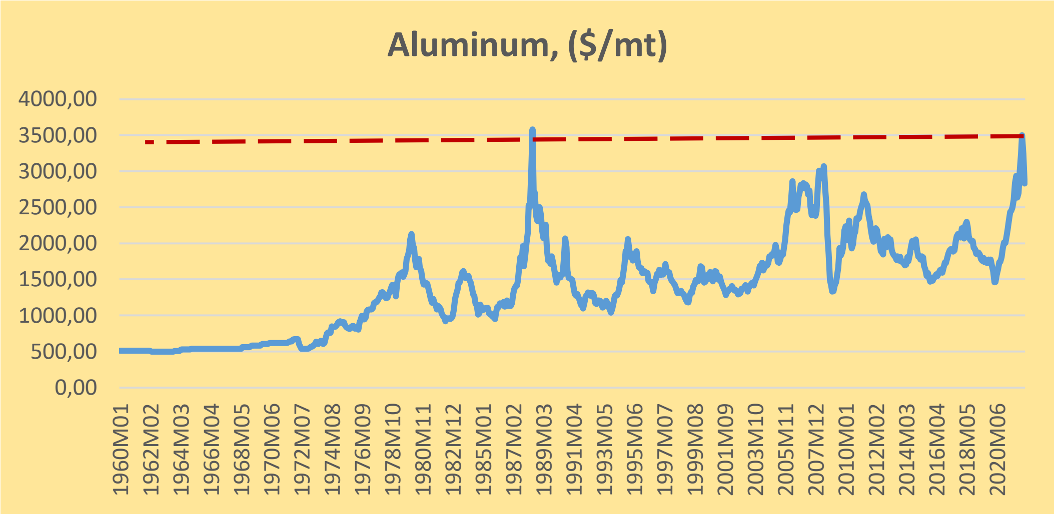
Recent surge in prices: a structural shock?

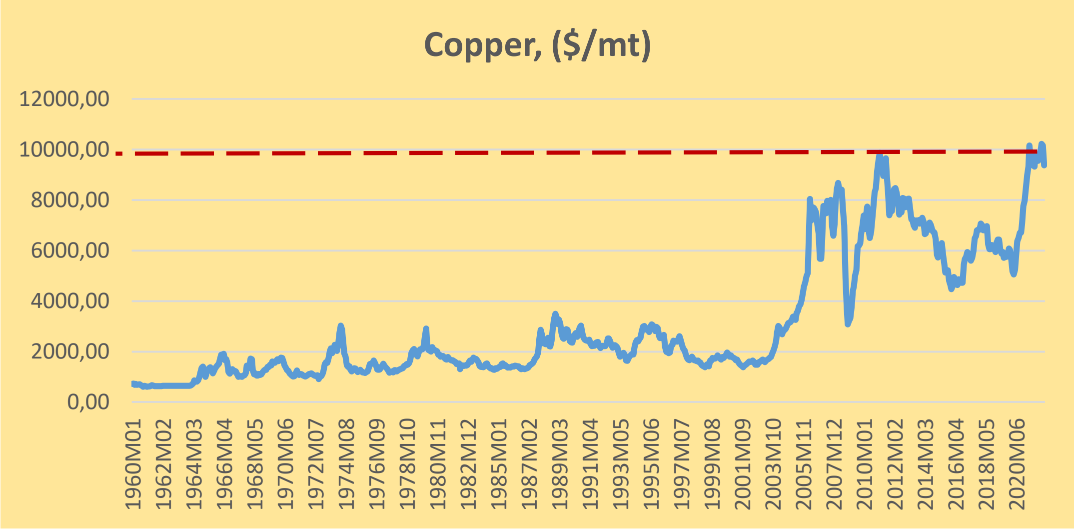
(nominal prices 1960/Jan-2022/May)

May 2022: nominal prices not the highest in decades (only gas Europe)

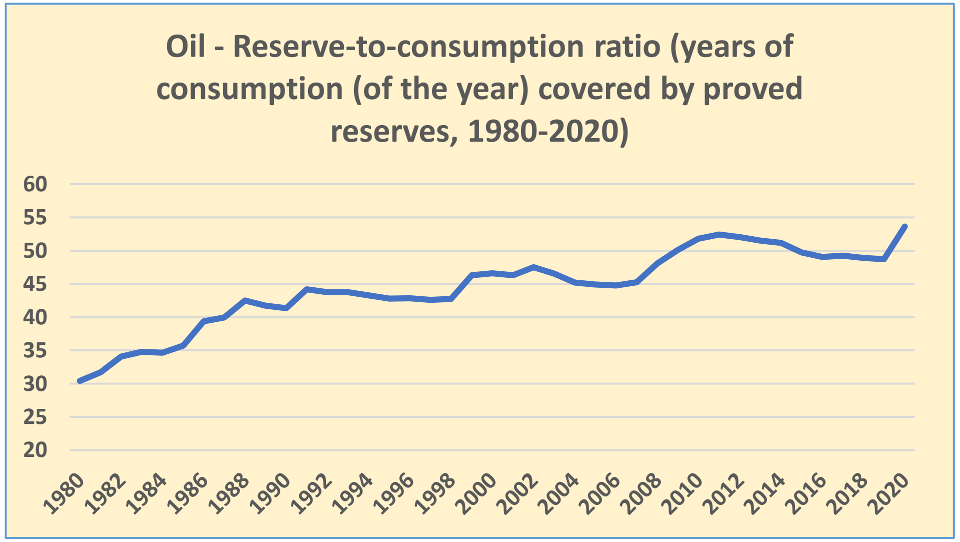


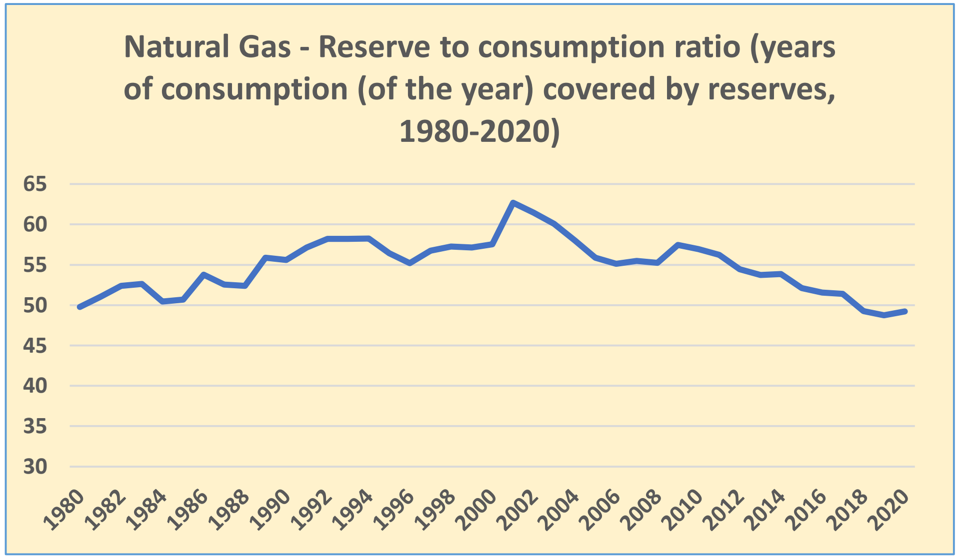






Weak scarcity signals from NRRs availability





	Ratio reserves/prodution 2019 (= No. years of reserves)	Ratio reserves/prodution 1994 (= No. years of reserves)	Change in world production 2019/1994 (%)	Change in world reserves 2019/1994 (%)	Change in years of production covered by reserves (No. years)
Antimony (tons)	11,73	39,62	52,83	-54,76	-27,89
Bauxite (000 tons)	225,56	214,95	24,30	30,43	10,61
Chromium (000 tons)	12,72	386,62	368,13	-84,59	-373,90
Cobalt (tons)	49,31	216,22	678,38	77,50	-166,91
Copper (000 tons)	42,65	32,87	116,33	180,65	9,77
Gold (tons)	16,06	19,13	43,48	20,45	-3,07
Natura graphite (tons)	290,91	29,21	52,99	1423,81	261,70
Iron ore (crude, 000 tons)	55,26	65,00	52,00	29,23	-9,74
Lead (000 tons)	18,64	24,29	68,57	29,41	-5,64
Lithium (tons)	244,19	360,66	1309,84	854,55	-116,47
Manganese (000 tons)	66,33	94,58	172,60	91,18	-28,25
Molybdenum (tons)	61,22	52,88	182,69	227,27	8,34
Nickel (tons)	36,02	51,88	188,08	100,00	-15,86
Phosphate rocks (000 tons)	312,78	85,94	77,34	545,45	226,84
Platinum gorup metals (kg)	167,07	246,48	81,78	23,21	-79,41
Rare hearts (tons)	545,45	155,04	241,09	1100,00	390,42
Silver (tons)	18,87	20,14	90,65	78,57	-1,28
Tin (tons)	14,53	38,04	60,87	-38,57	-23,52
Tungsten (000)	40,57	80,77	222,31	61,90	-40,20
Vanadium (tons)	253,46	294,99	156,05	120,00	-41,53
Zinc (000 tons)	19,69	20,56	86,49	78,57	-0,87

33 minerals and metals

- **Ratio reserves/production 2019 (= No. years of reserves):** 19 > 40 years; 10 > 100 years; 8 < 20 years
- **Change in world production 2019/1994 (%):** 15 > 100%
- **Change in world reserves 2019/1994 (%):** 5 decrease; 12 > 100% increase
- **Change in years of production covered by reserves (No. years):** 22 decrease

(elaborations from US Geological Survey)

Weak price-based policy signals (MBI)

- Carbon pricing: **Large endorsement** of CP (IMF, OECD, EC, WB, B20, ...)
- **Substantially lower** than those needed for Paris Agreement targets
  - *High-Level Commission on Carbon Prices: prices at **US$40–80/tCO2 by 2020** and **US$50–100/tCO2 by 2030** required to reduce emissions towards the Paris Agreement targets*
- **< 5%** of GHG emissions covered by a carbon price are within the range
- **Half** of covered emissions priced at **less than US$10/tCO2**
- **IMF**: global average carbon price is **US$2/tCO2**

N. Stern (2021): Carbon pricing not the only instrument

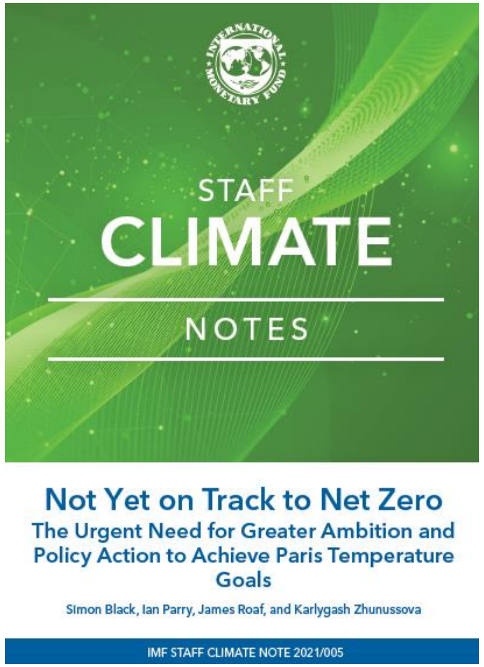
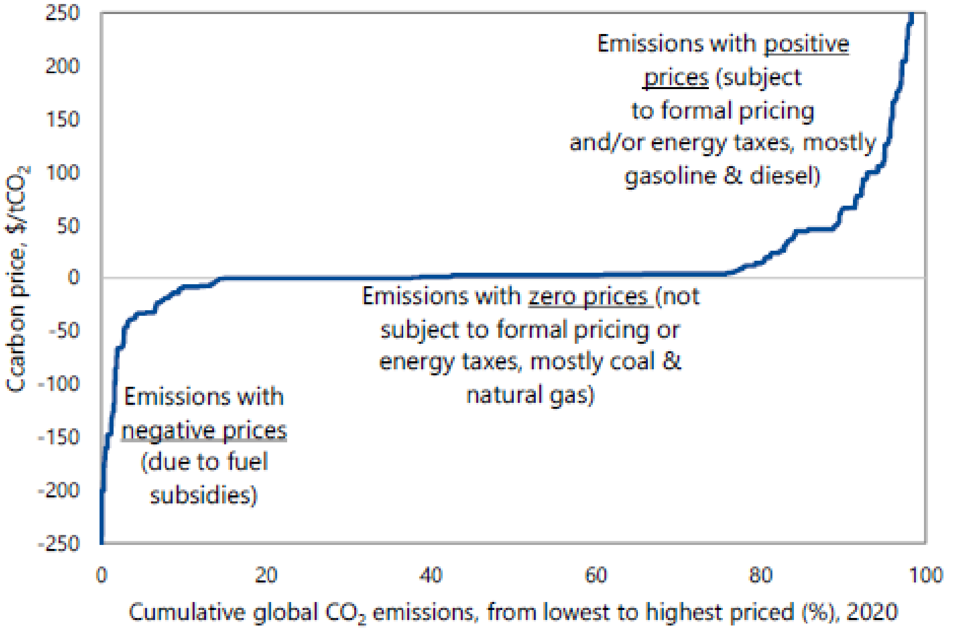


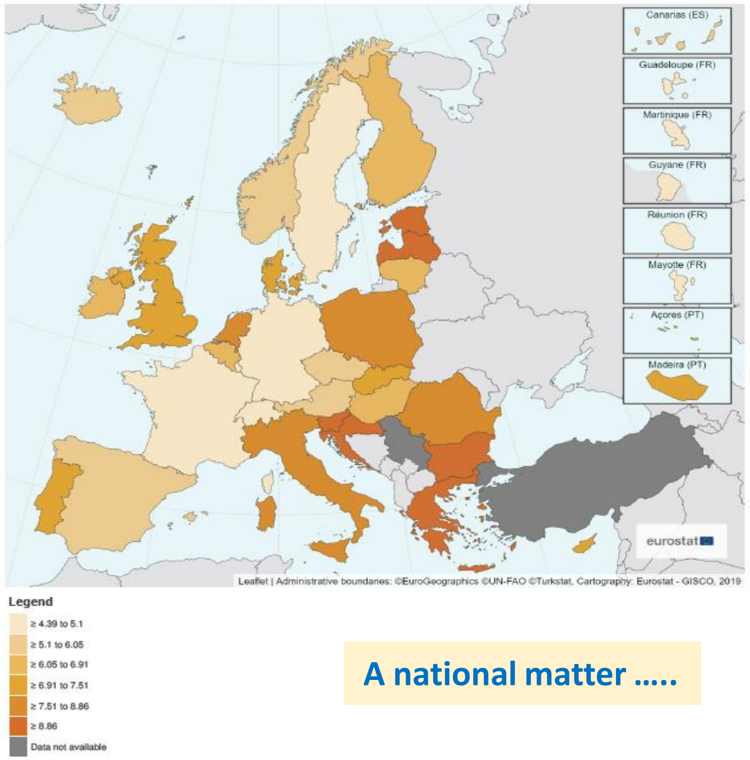
Figure 2. Global Average Carbon Prices on Fossil Fuels from Pricing & Taxes, 2020



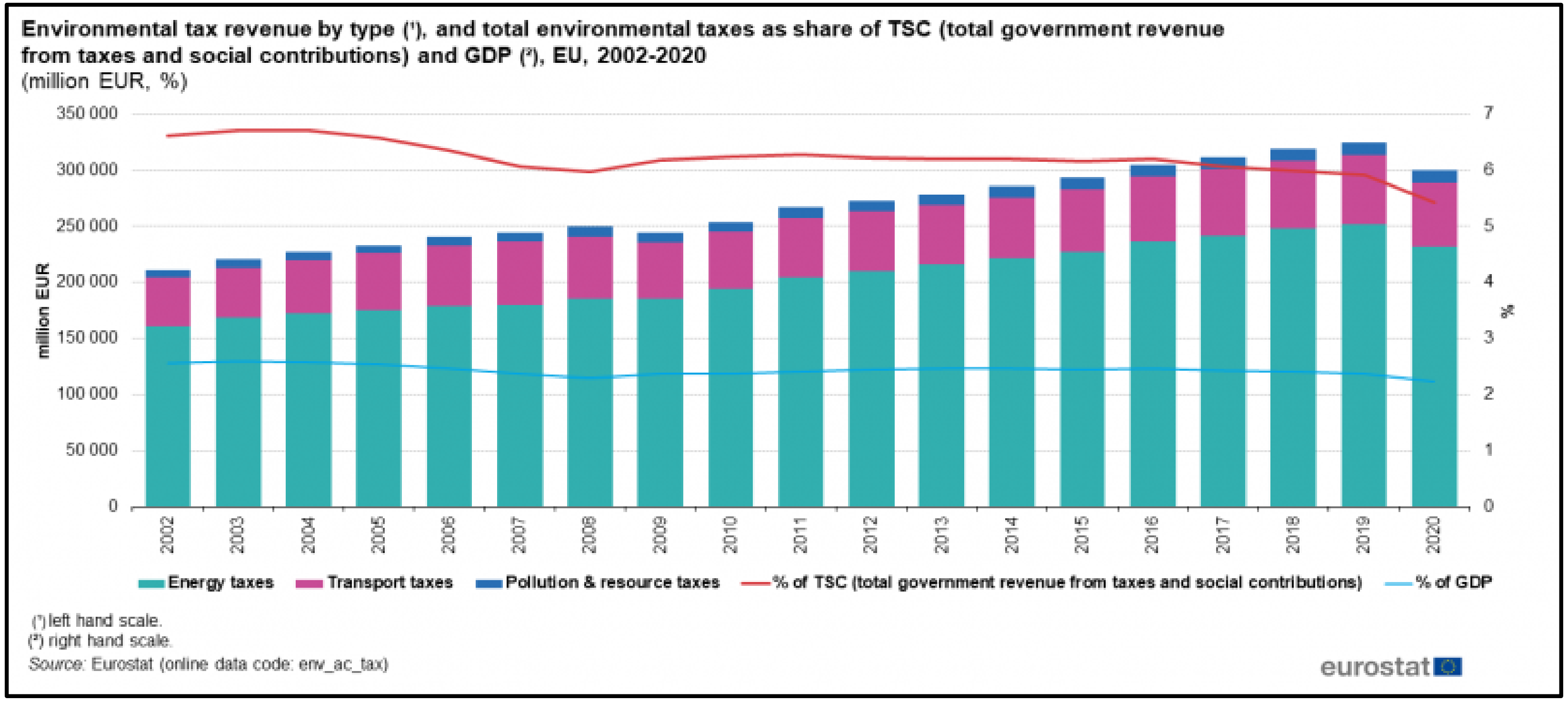
Source: IMF staff.
Note: Shows global average carbon price from carbon taxes/emissions trading systems plus fuel taxes/explicit subsidies by cumulative CO_2 emissions.

Environmental taxation decreasingly important !

- Large support in policy discussions
- But env tax revenues are decreasing as percent of total taxes!



A national matter …..



Policies do matter for eco-innovation

Contents lists available at ScienceDirect
Research Policy
journal homepage: www.elsevier.com/locate/respol

Characterizing the policy mix and its impact on eco-innovation: A patent analysis of energy-efficient technologies

Valeria Costantini[a,b,*], Francesco Crespi[a,c], Alessandro Palma[d,e]

[a] Roma Tre University, Rome, Italy
[b] SEEDS, Italy
[c] BRICK, Collegio Carlo Alberto, Turin, Italy
[d] CEIS – University of Tor Vergata, Rome, Italy
[e] IEFE – Bocconi University, Milan, Italy

Eni Enrico Mattei

Examining the Factors Influencing Environmental Innovations

J Evol Econ (2015) 25:671–705
DOI 10.1007/s00191-015-0407-7
REGULAR ARTICLE

SMEs and barriers to Eco-innovation in the EU: exploring different firm profiles

Giovanni Marin[1,2] · Alberto Marzucchi[3] · Roberto Zoboli[1,3]

Published online: 29 April 2015

Abstract Eco-innovation is an explicit aim of major EU policy strategies. Many environmental policies *de facto* require firms to eco-innovate to comply with policy requirements, while the overlap between policy-driven and market-driven eco-innovation strategies is increasingly important for many firms. Barriers to eco-innovation can then emerge as a critical factor in either preventing or stimulating EU strategies, policy implementation, and the green strategies of firms. In this paper we focus on EU-27 SMEs. We single out and explore different firm profiles, considering eco-innovation barriers and engagement. Our analysis is based on a particularly suitable dataset; the

INNOVAR JOURNAL

Environmental Policy Instruments and Eco-innovation: An Overview of Recent Studies[1]

Ángeles Pereira Sánchez
Máster en Desarrollo Económico e Innovación
Universidade de Santiago de Compostela
Galicia, España
ICEDE - Innovación, Cambio Estrutural e Desenvolvemento
Correo electrónico: angeles.pereira@usc.es

Available online at www.sciencedirect.com
SCIENCE DIRECT
Ecological Economics 58 (2006) 318–337
ECOLOGICAL ECONOMICS

ANALYSIS

Economic instruments and induced innova[...] The European policies on end-of-life veh[...]

Massimiliano Mazzanti[a,*], Roberto Zoboli[b]

[a] Department of Economics Institutions and Territory, University of Ferrara, via del Gregorio 13, [...]
[b] CERIS-DSE, National Research Council of Italy, via Bassini 15, 20133 Milan, and Catholic Un[...]

Received 15 October 2002; received in revised form 1 June 2005; accepted 13 June [...]
Available online 26 September 2005

Abstract

The paper addresses the mechanisms by which specific economic instruments based on [...] principle' (PRP) can influence innovation when environmental policy has impact on very co[...] We consider the EU policy on End-of-Life Vehicles (Directive 2000/53/EC on ELVs) as a represent[...] industry–PRP instrument' dynamic efficiency problems. In order to achieve ambitious policy [...] recycling/reuse, interrelated sequences of single innovations in both upstream (car making) and [...] recovery) should take place. We explore the extent to which the introduction of a free take-back (F[...] industrial actors in contributing to 'innovation paths' that are still marked by technological uncer[...] and different cost-benefit balances for actors themselves. We conclude that differently from static [...] and its formulation is neutral with respect to policy effectiveness, the dynamic efficiency of EIs in [...] both on where, along the 'production-to-waste chain', and how, in terms of net cost allocati[...] introduced. Consequently, in order to generate a 'policy-desired' innovation path, the way in wh[...] allocated to a certain industry is transmitted to other industries—whether upward or downwar[...] relevant. Disregarding these effects can imply a 'dissipation' of innovation incentives, and the gene[...] rents' for some actors cannot be ruled out. Policies based on PRP should consider EIs in co[...] voluntary agreements.

Keywords: Environmental policy; Economic instruments; Induced innovation; Dynamic efficiency; Recycling[...]

JEL classification: L620; O130; O310; O380

Research Policy 44 (2015) 577–595
Contents lists available at ScienceDirect
Research Policy
journal homepage: www.elsevier.com/locate/respol

Demand-pull and technology-push public support for eco-innovation: The case of the biofuels sector☆

Valeria Costantini[a,*], Francesco Crespi[a,b], Chiara Martini[c], Luca Pennacchio[d]

[a] Department of Economics, Roma Tre University, Italy
[b] BRICK, Collegio Carlo Alberto, Italy
[c] Italian National Agency for New Technologies, Energy and Sustainable Economic Development (ENEA), Italy
[d] Department of Economics and Statistics, University of Naples Federico II, Italy

ARTICLE INFO

Article history:
Received 31 January 2013
Received in revised form 14 October 2014
Accepted 30 December 2014
Available online 23 January 2015

JEL:
O31
O34
Q42
Q55

Keywords:
Eco-innovation
Biofuels
Demand-pull
Technology-push
Environmental policy
Patents

ABSTRACT

The purpose of this paper is to explore the differentiated impact of demand-pull and technology-push policies in shaping technological patterns in the biofuels sector. The empirical analysis is based on a novel and original database (BioPat) containing patents in the field of biofuels selected using appropriate keywords and classified according to the technological content of the invention. Our results generally show that technological capabilities and environmental regulation spur innovative activities in the biofuels sector. Both demand-pull and technology-push factors are found to be important drivers of innovation in the biofuels sector. However, technology exploitation activities in first generation technologies are found to be mainly driven by quantity and price-based demand-pull policies. On the contrary, the pace of technology exploration efforts in advanced generation biofuels is shown to react positively to price-based demand-pull incentives but also to technology-push policy. The clear diversity in the impact of different public support instruments provides new insights which fuel discussion on the optimal policy mix debate and offers new elements for the design of future policy strategies.

Green technologies, complementarities, and policy

Nicolò Barbieri[a,d,*], Alberto Marzucchi[b], Ugo Rizzo[c,d]

[a] Department of Economics and Management, University of Ferrara, Ferrara, Italy
[b] Gran Sasso Science Institute, Social Sciences, L'Aquila, Italy
[c] Department of Mathematics and Computer Science, University of Ferrara, Ferrara, Italy
[d] Sustainability, Environmental Economics and Dynamics Studies - SEEDS,

Abstract

The present study explores the technological complementarities between green and non-green inventions. First, we look at whether inventive activities in climate-friendly domains depend on patenting in related technological domains that are not green. Based on patent data filed over the 1978–2014 period, we estimate a spatial autoregressive model using co-occurrence matrices to capture technological interdependencies. Our first finding highlights that the development of green technologies strongly relies on advances in other green and in particular non-green technological domains, whose relevance for the green economy is usually neglected. Building on this insight, we detect the non-green complementary technologies that co-occur with green ones and assess whether environmental policies affect this particular instantiation of technologies at the country level. The results of the instrumental variable approach confirm that while environmental policies spur green patenting, they do not displace the development of the non-green technological pillars upon which green inventions develop.

Keywords:
Green technology, patent data, environmental policy, network-dependent innovation
JEL: H23, O31, Q58, Q55

Policies drive the sustainability transition (and the CE) in the EU

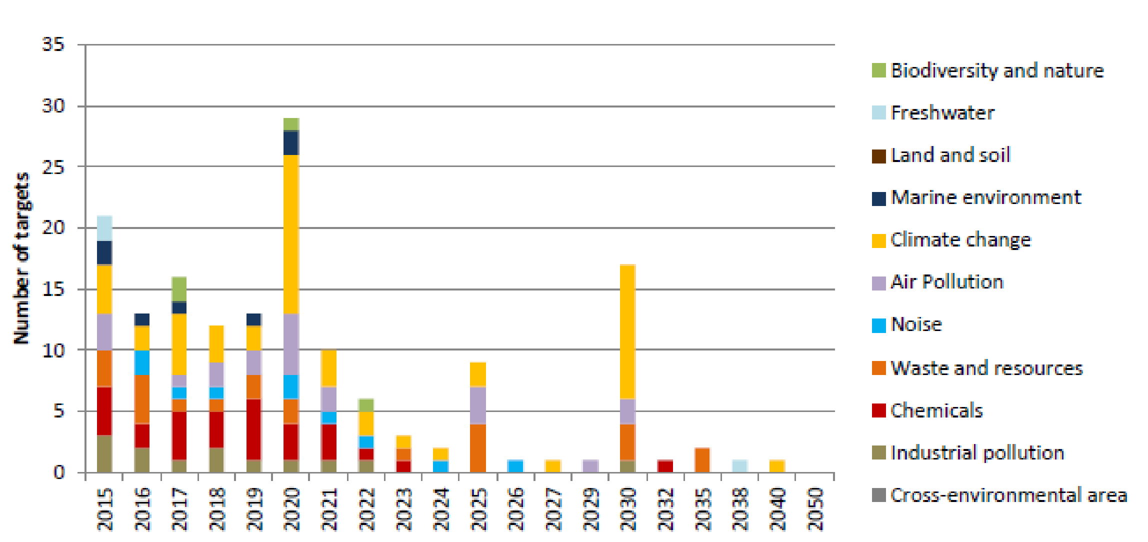
Before the European Green Deal (2019)

Targets and objectives in EU legislation:

- 159 legally binding targets and 87 non-binding objectives across 11 environmental themes up to 2050
- Highest number of targets: climate change (51 targets), chemical pollution (27 targets) and **waste and resources (23 targets)**
- Economic sectors: **industry** (2 objectives and 97 targets) and transport (14 objectives and 35 targets)

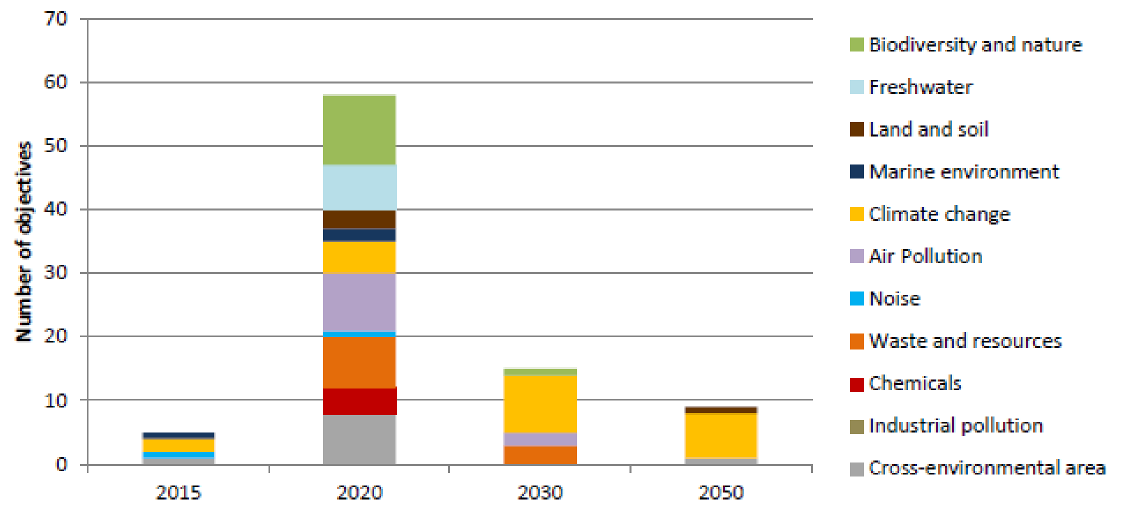
Source: S. Paleari and A. Reichel 2019

Figure 4.1: Binding environmental targets 2015-2050



Source: own elaboration

Figure 4.2: Non-binding environmental objectives 2015-2050



Source: own elaboration

The EU EGD: A flow of new policy signals across all sectors

EGD, <u>before</u> the 'Fit-for-55' (July 2021):

- 177 measures/strategic documents/legislative proposals expected (new/revision)
- 28 in CC and energy
- **<u>15 in Waste and resources</u>**
- 17 in Chemicals
- 28 in Industry, products, value chains
- Large part in 2021 and 2022


Eionet Report - ETC/WMGE 2021/8

Sustainability transition and the European Green Deal: A macro-dynamic perspective

December 2021

European Environment Agency
European Topic Centre on Waste and Materials in a Green Economy

Authors:
Nicolò Barbieri, Ilaria Beretta, Valeria Costantini, Alessio D'Amato, Marianna Gilli, Giovanni Marin, Massimiliano Mazzanti, Simone Tagliapietra, Roberto Zoboli, Mariangela Zoli (SEEDS), Susanna Paleari (IRCrES-CNR), Andrea M. Bassi (KnowlEdge) and Stefan Ulrich Speck (EEA)

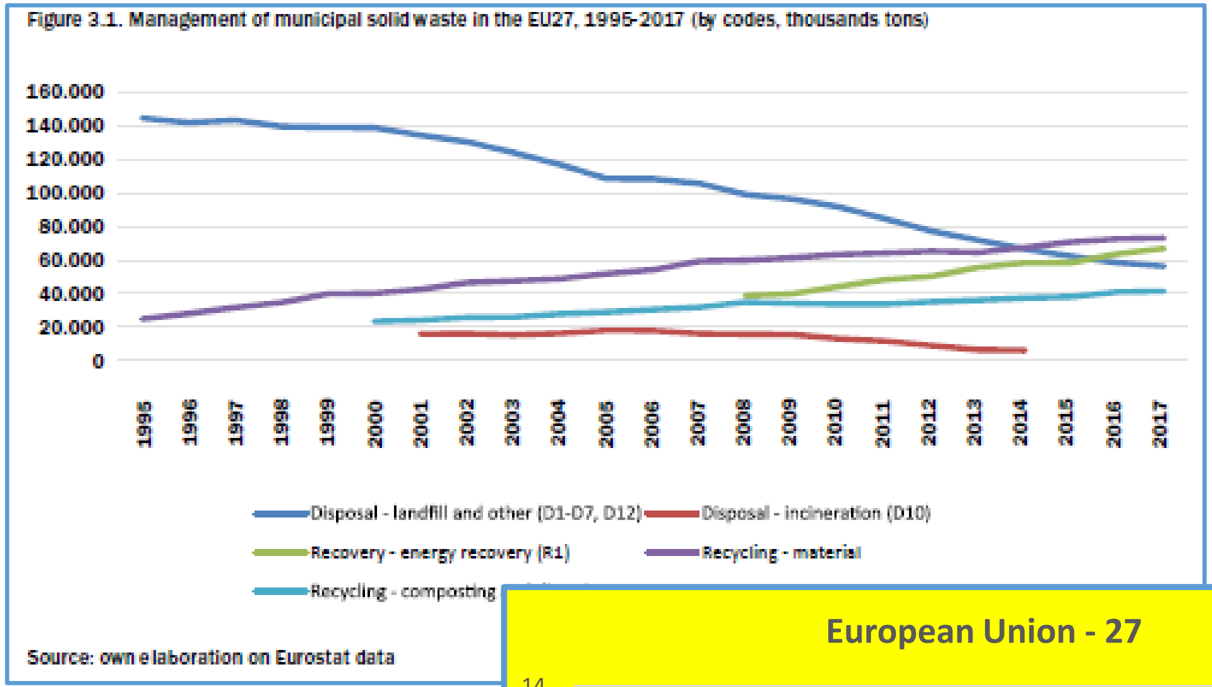
ETC/WMGE consortium partners: Flemish Institute for Technological Research (VITO), CENIA, Collaborating Centre on Sustainable Consumption and Production (CSCP), Research Institute on Sustainable Economic Growth of National Research Council (IRCrES), The Public Waste Agency of Flanders (OVAM), Sustainability, Environmental Economics and Dynamic Studies (SEEDS), VTT Technical Research Centre of Finland, Banson Communications Ireland (BCI), The Wuppertal Institute for Climate, Environment, Energy (WI), Slovak Environment Agency (SEA)

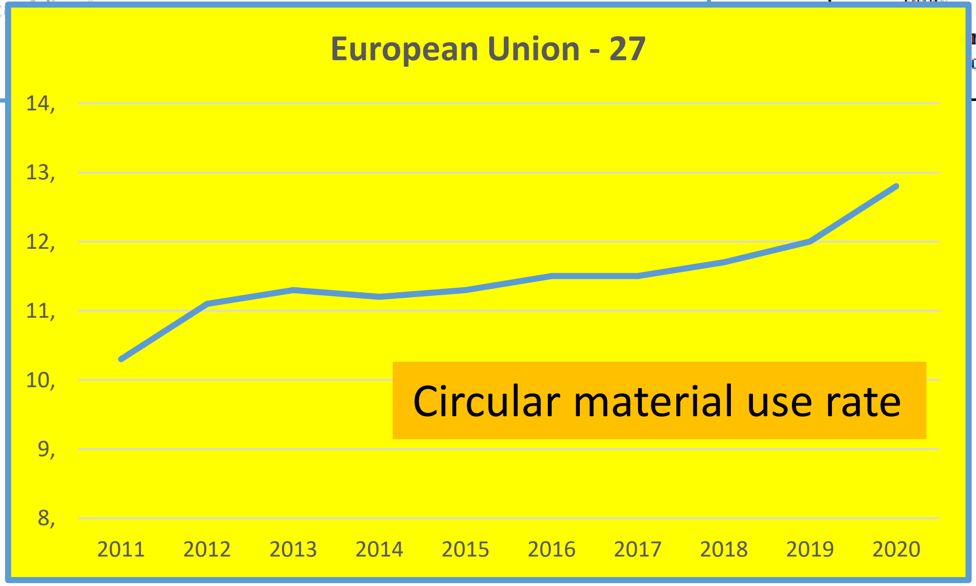
Environmental legislative/policy measures to be adopted according to the EU Green Deal and the related strategic documents/legislative proposals	No. of meaures/ proposals/strategic docs
CLIMATE CHANGE	9
ENERGY (including biofuels)	19
TRANSPORT (including GHG emissions, air pollution, noise)	11
AIR POLLUTION & AIR QUALITY (excluding transport)	5
FRESHWATER	3
MARINE WATER AND ENVIRONMENT (including fishery/aquaculture)	5
WASTE AND RESOURCES	15
BIODIVERSITY AND SOIL	10
CHEMICALS	17
CROSS-CUTTING (environmental and non-environmental)	3
AGRICULTURE	2
CONSUMERS and PUBLIC PROCUREMENT	12
EXTERNAL POLICY	14
FINANCE	6
FISCAL POLICY	3
FISHERY and AQUACULTURE	1
INDUSTRY, PRODUCTS, VALUE CHAINS	28
COMPETITION	4
JUSTICE	3
TRANSPORT (non-environmental legislation)	6
OTHER	1
Total	177

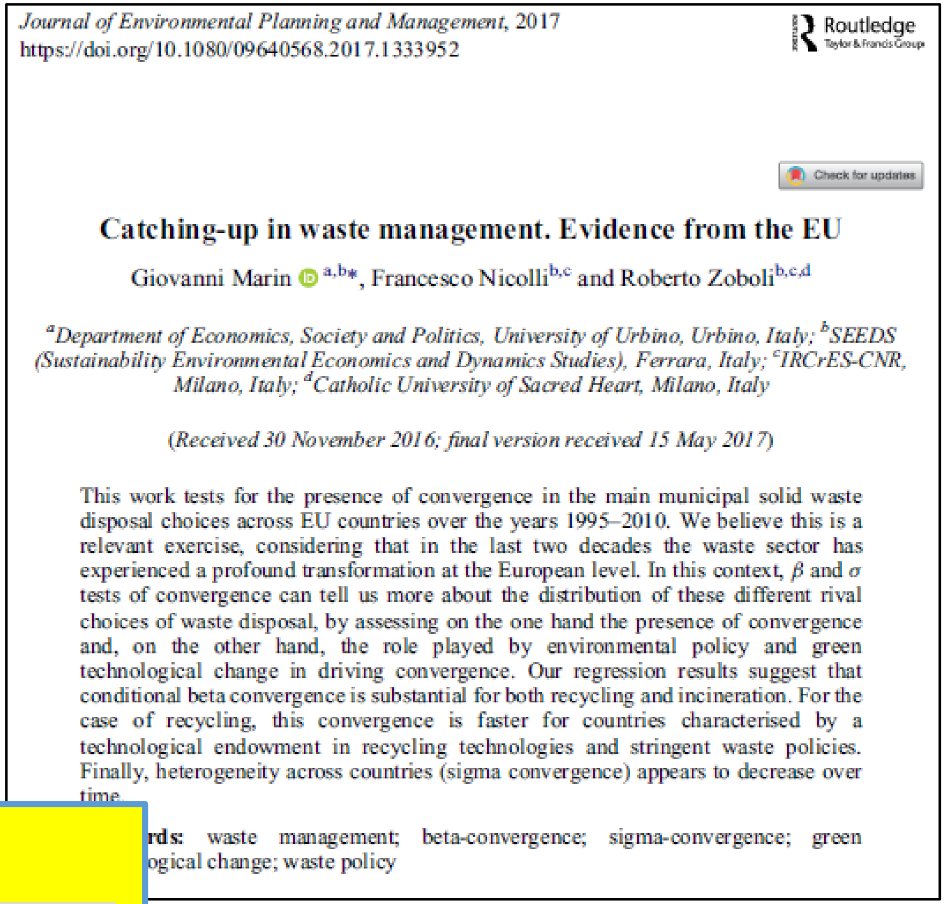
Source: S. Paleari, in ETC/WMGE, 2021

Synergy with: Macro recovery policies (post-COVID 19)
Synergy with: Sustainable finance, climate risk in finance

‘Waste’ policies (‘old CE’) gradually succesful







Journal of Environmental Planning and Management, 2017
https://doi.org/10.1080/09640568.2017.1333952

Routledge
Taylor & Francis Group

Check for updates

Catching-up in waste management. Evidence from the EU

Giovanni Marin[a,b]*, Francesco Nicolli[b,c] and Roberto Zoboli[b,c,d]

[a]*Department of Economics, Society and Politics, University of Urbino, Urbino, Italy;* [b]*SEEDS (Sustainability Environmental Economics and Dynamics Studies), Ferrara, Italy;* [c]*IRCrES-CNR, Milano, Italy;* [d]*Catholic University of Sacred Heart, Milano, Italy*

(*Received 30 November 2016; final version received 15 May 2017*)

This work tests for the presence of convergence in the main municipal solid waste disposal choices across EU countries over the years 1995–2010. We believe this is a relevant exercise, considering that in the last two decades the waste sector has experienced a profound transformation at the European level. In this context, β and σ tests of convergence can tell us more about the distribution of these different rival choices of waste disposal, by assessing on the one hand the presence of convergence and, on the other hand, the role played by environmental policy and green technological change in driving convergence. Our regression results suggest that conditional beta convergence is substantial for both recycling and incineration. For the case of recycling, this convergence is faster for countries characterised by a technological endowment in recycling technologies and stringent waste policies. Finally, heterogeneity across countries (sigma convergence) appears to decrease over time.

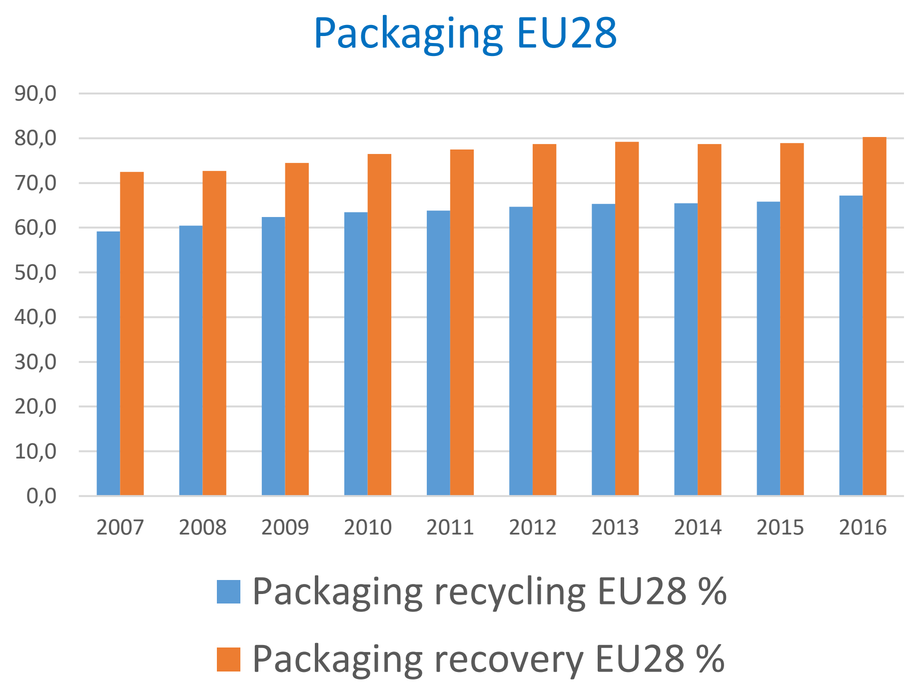
…rds: waste management; beta-convergence; sigma-convergence; green …ogical change; waste policy

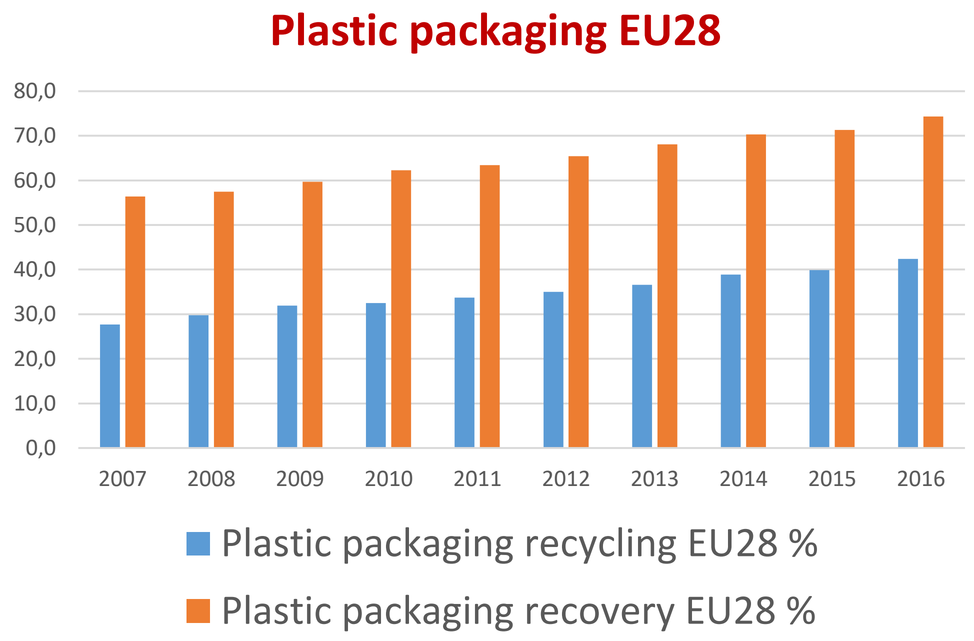
Policy issues 1:
Plastics

Successes and failures of ‘closing-the-loop’ policies

High collection, high recycling

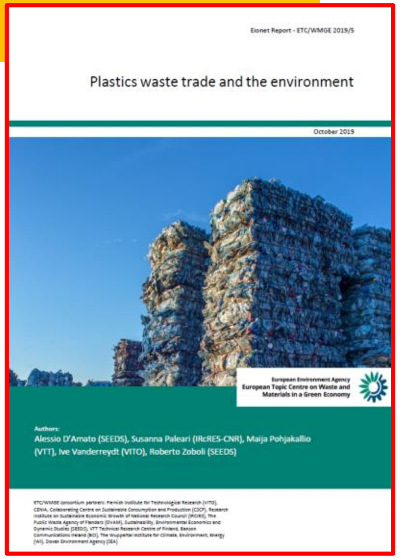
High collection, low recycling



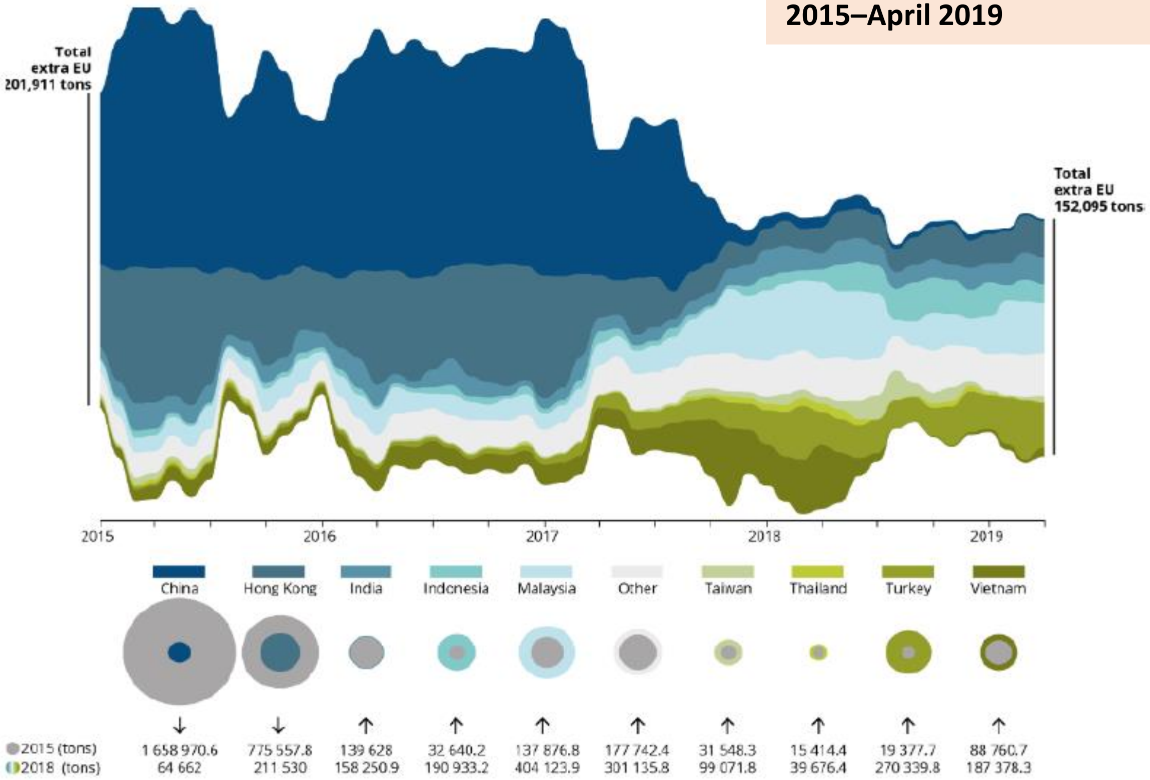


End of game for plastics waste trade

- About **half** of the plastic waste collected in the EU sent abroad for treatment (European Commission 2018), large part to **China**
- **Chinese trade ban 2018 (and other bans):** waste flows partly redirected to extra-EU destinations, also redirections of intra-EU trad
- **High pressure** on the domestic EU market, **the 'plastics crisis'**



Extra-EU plastic waste exports by receiving country, tonnes, January 2015–April 2019



Policy responses 1: The plastics strategy (2018)

Objectives:

- ✓ **All plastic packaging is either reusable or can be recycled** in a cost-effective manner and **more than half of plastics waste generated in Europe is recycled by 2030**
  - ✓ *Sorting and recycling capacity of plastics has increased fourfold since 2015, with 200,000 new jobs expected by 2030*
- ✓ **Better design of plastic products**
- ✓ **Better quality recyclates**

*Stakeholders asked to submit **voluntary pledges** for **10 million tons of recycled plastics** into new products by 2025*

*End of 2018: pledges from **70 companies** and business organisations*

*Pledges can achieve the target (EC, 2019c) **if delivered as expected** (dialogue in the Circular Plastics Alliance)*

The narrative on the 'plastics economy we want'

'A vision for Europe's new plastics economy'

A smart, innovative and sustainable plastics industry, where design and production fully respects the needs of reuse, repair, and recycling, brings growth and jobs to Europe and helps cut EU's greenhouse gas emissions and dependence on imported fossil fuels.

- Plastics and products containing plastics are designed to allow for greater durability, reuse and high-quality recycling. By 2030, all plastics packaging placed on the EU market is either reusable or can be recycled in a cost-effective manner.
- Changes in production and design enable higher plastics recycling rates for all key applications. By 2030, more than half of plastics waste generated in Europe is recycled. Separate collection of plastics waste reaches very high levels. Recycling of plastics packaging waste achieves levels comparable with those of other packaging materials.
- EU plastics recycling capacity is significantly extended and modernised. By 2030, sorting and recycling capacity has increased fourfold since 2015, leading to the creation of 200 000 new jobs, spread all across Europe.
- Thanks to improved separate collection and investment in innovation, skills and capacity upscaling, export of poorly sorted plastics waste has been phased out. Recycled plastics have become an increasingly valuable feedstock for industries, both at home and abroad.
- The plastics value chain is far more integrated, and the chemical industry works closely with plastics recyclers to help them find wider and higher value applications for their output. Substances hampering recycling processes have been replaced or phased out.
- The market for recycled and innovative plastics is successfully established, with clear growth perspectives as more products incorporate some recycled content. Demand for recycled plastics in Europe has grown four-fold, providing a stable flow of revenues for the recycling sector and job security for its growing workforce.
- More plastic recycling helps reduce Europe's dependence on imported fossil fuel and cut CO_2 emissions, in line with commitments under the Paris Agreement.
- Innovative materials and alternative feedstocks for plastic production are developed and used where evidence clearly shows that they are more sustainable compared to the non-renewable alternatives. This supports efforts on decarbonisation and creating additional opportunities for growth.
- Europe confirms its leadership in sorting and recycling equipment and technologies. Exports rise in lockstep with global demand for more sustainable ways of processing end-of-life plastics.
- This data corresponds to building about 500 new sorting and recycling plants (source: Plastics Recyclers Europe).

Source: EC, A European Strategy for plastics in the circular economy, 2018

Policy response 2

‘Directive on Single-use plastic products’ (2019)

Product by product, even multiple instruments together:

- Prohibition to place on the market
- Measurable reduction in consumption
- Collection targets
- Marking requirements
- Separate collection targets
- Extended producer responsibility
- Mandatory targets on the recycled content (beverage containers)

EU (2019a). Directive (EU) 2019/904 of the European Parliament and of the Council of 5 June 2019 on the reduction of the impact of certain plastic products on the environment; OJ L 155, 12.6.2019, p. 1–19.

Annex II: Measures provided by the proposed Directive on single-use plastic products and related deadlines for implementation

	Single-use plastic products	Prohibition to place on the market	Measurable reduction in consumption	Separate collection target	Marking requirements	EPR	Product requirements (attached caps/lids)	Product requirements (minimum recycled content)	Awareness raising
Beverage packaging and products	Beverage cups and containers made of EP	*2021 (pending)*							
	Beverage containers (up to 3l)			2025 (77%) 2029 (90%)		End 2024	*2024 (pending)*		*2021 (pending)*
	- PET bottles							2025 (25%)	
	- Beverage bottles							2030 (30%)	
	Composite beverage packaging					End 2024	*2024 (pending)*		*2021 (pending)*
	Beverage cups		2026		*2021 (pending)*	End 2024			*2021 (pending)*
	Beverage stirrers and straws	*2021 (pending)*							
Food packaging and products	Containers of food for immediate consumption made of EP	*2021 (pending)*							
	Containers of food for immediate consumption		2026			End 2024			*2021 (pending)*
	Cutlery, plates,	*2021 (pending)*							
	Packets/wrappers made from flexible material containing food for immediate consumption					End 2024			*2021 (pending)*
Sanitary items	Cotton bud sticks	*2021 (pending)*							
	Sanitary towels				*2021 (pending)*				*2021 (pending)*
	Wet wipes				*2021 (pending)*	End 2024			*2021 (pending)*
Other plastic products	Balloons					End 2024			*2021 (pending)*
	Sticks for balloons	*2021 (pending)*							
	Oxo-degradable plastic items	*2021 (pending)*							
	Lightweight plastic carrier bags					End 2024			*2021 (pending)*
	Tobacco products with filters				*2021 (pending)*	End 2024			*2021 (pending)*
	Fishing gear containing plastic			MS shall set target by *2021 (pending)*		End 2024			*2021 (pending)*

EP= expanded polystyrene

Source: own elaboration based on European Parliament and Council, 2019

Source: S. Paleari 2019 for ETC/WMGE

New CE Action Plan (COM 2020/98) (EGD)

PRIORITY AREAS

- Electronics
- Textiles
- Packaging
- **Plastics**
- Batteries
- ELVs
- Construction and demolition
- Food, water and nutrients

General

- Widen the Ecodesign Directive + Legislative proposal for a sustainable product policy initiative (2021), based on:
- Improve product durability, reusability, upgradability, reparability
- Ensure high quality of recycling and increase the recycled content in products
- Restricting single-use and countering premature obsolescence

Policy response 3: CE Action Plan – Plastics

Planned measures	Deadline
➢ Proposal of **mandatory requirements for recycled content** and waste reduction measures for plastic materials in key products such as <u>packaging, construction materials and vehicles</u> ➢ Measures to tackle **intentionally added microplastics** ➢ Rules for the **safe recycling into food contact materials of plastic materials other than PET** ➢ Development of a **regulatory framework for biodegradable and bio-based or compostable plastics**	2020-2022

Policy response 3: CE Action Plan – Packaging

Planned measures	Deadline
➢ **Revision of the Packaging Waste Directive** (Directive 94/62/EEC) to reinforce the **mandatory essential requirements** for packaging and reduce **over-packaging** and packaging waste ➢ Improvement of the **design for re-use and recyclability of packaging**. ➢ Reducing **the complexity of packaging materials** (number of materials and polymers used) ➢ Introducing an **EU-wide labelling that** facilitates the correct **separation of packaging waste at source** ➢ **Make drinkable tap water accessible in public places**	2020-2022

Less consumption Vs more recycling: Which is pushed by policies?

Less consumption/production = <u>Material market-reducing</u>

Plastic strategy 2018
- ✓ All packaging *reusable(/recyclable)*

Single use plastics 2019
- ➢ Prohibition to place on the market
- ➢ Measurable reduction in consumption
- ➢ Marking requirements
- ➢ Durability

New AP CE 2020
- Durability, reusability, upgradability, reparability
- Restricting single-use
- Countering premature obsolescence
- Reduce over-packaging
- Drinkable tap water accessible in public places
- Design for re-use

More recycling = <u>Material market-preserving</u>

Plastic strategy 2018
- ✓ All packaging (reusable/)recyclable
- ✓ > 50% plastics waste recycled by 2030
- ✓ Better design of plastic products
- ✓ Better quality recyclates
- ✓ Collection targets

Single use plastics 2019
- ➢ Separate collection targets
- ➢ **<u>Extended producer responsibility</u>** ➡
- ➢ Mandatory targets on recycled content (beverage)

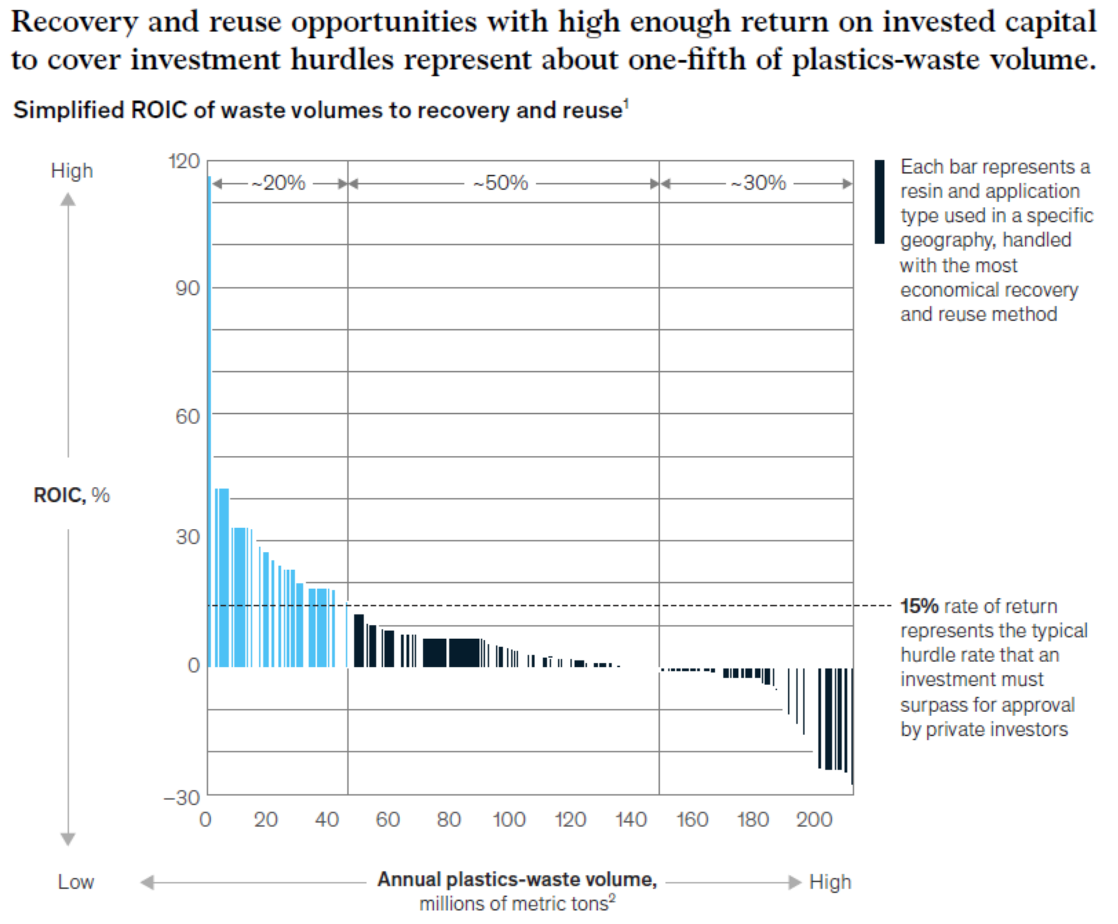
New AP CE 2020
- ➢ High quality recycling
- ➢ Increase recycled content in products
- ➢ Mandatory requirements for recycled content
- ➢ Biodegradable and bio-based or compostable plastics
- ➢ Labelling for separation of pack waste at source
- ➢ Design for recyclability

How to preserve the plastics market?

- “ *If we add in capital costs as well as operating costs, our analysis shows that, **at an oil price of $60 per barrel, only a limited number of plastics recycling opportunities are currently value creating in themselves**»*

- *” **But there are also applications for which the cost incurred in recycling, with no possibility of earning a profitable return, could be deemed acceptable because the plastic used there simply does the most economical, as well as the most carbon-efficient, job.**»*

McKinsey & Company, Plastics recycling: Using an economic-feasibility lens to select the next moves, March 2020



[1]ROIC: return on invested capital. Simplified ROIC (based on calculation of earnings before interest, taxes, depreciation, and amortization divided by capital expenditures) of waste volumes to recovery and reuse, including full system cost and revenues (ie, operating and capital costs of collection, sorting, and
reprocessing and revenue from sales of core products and byproducts, including fuel, energy, monomer, and polymer). The chart only includes volumes that currently go to landfill/incineration after collection and sorting.
[2]Metric tons: 1 metric ton = 2,205 pounds.

EPR – Extended Producer Responsibility: A way to preserve the plastics market?

- A special 'economic instrument' (MBI) (see Mazzanti and Zoboli, 2006)
- Material/product industry has the cost of collection/ recycling
  - Directives on: ELVs, WEEE and waste batteries (EU 2000, 2012, 2006)
  - Packaging Waste by 2024 *(most Member States have in place since a long time)*
  - Directive single-use plastic products (EU, 2019): 2023/2024 for selected products
  - Some Member States (e.g. France, 2015): EPR schemes for textiles, furniture, graphic paper

Large evidence from research literature:

- EPR induced remarkable increases in separate collection/recycling (e.g. Bio by Deloitte 2014, Massarutto 2014, OECD 2014 and 2016, Walls 2006)
- 20 years of EPR schemes: Secondary markets and closed-loop value chains created (exceptions, e.g. some plastics)

Overcoming barriers to step-up secondary material markets

EEA Report (forthcoming 2022)

EPR schemes have had successful results in many countries, contributing to reduced waste generation and disposal and improved recycling rates (IEEP, 2017). Nevertheless, the success of EPR schemes has also varied widely across countries and some weaknesses can be identified (OECD, 2016).

EPR schemes are associated with more efficient, separate collection schemes for specific waste streams, including plastic packaging (Bonnet, 2017), contributing to reduced disposal and increased recycling rates for the materials concerned (IEEP, 2017; Bonnet, 2017; OECD, 2016; Plastics Europe, 2016). IEEP (2017) did three case studies (France, Italy and Belgium), showing that the recycling rates for plastic packaging waste gradually increased after the introduction of EPR.

Policy issues 2:
RES Vs ‘material’ CE in the bioeconomy

A NEXUS approach: Looking at the (policy) interactions

- Large synergies CE - Bioeconomy: the CE can **save bioresources** by using **biowaste** as input
- Decarbonisation: biomass-based **RES** (energy/biofuels) can create **pressures/conflicts on virgin bioresources**
- CE can provide **waste-based feedstocks** for **RES**, reducing demand for **virgin bioresources**


October 2019

FEEM

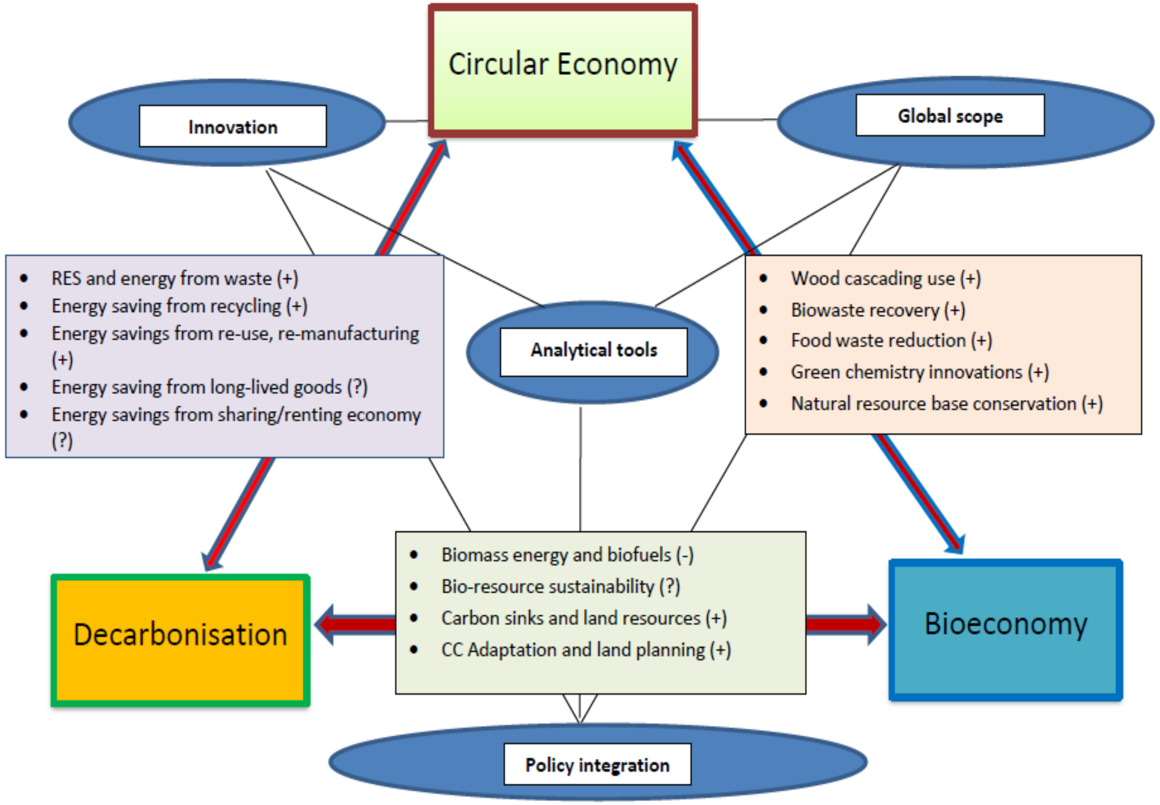
Report

Towards an Innovation-intensive Circular Economy. Integrating research, industry, and policies

Roberto Zoboli, Catholic University, Milan, and SEEDS

with contributions from
Nicolò Barbieri, University of Ferrara and SEEDS
Claudia Ghisetti, Catholic University and SEEDS
Giovanni Marin, University of Urbino and SEEDS
Susanna Paleari, IRCrES-CNR

Edited by Stefano Pareglio, Catholic University, Milan, and FEEM

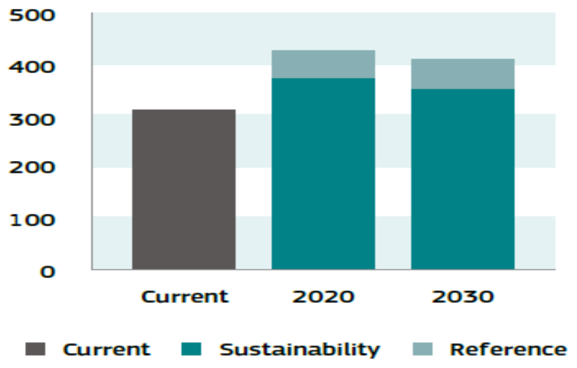


Source: Zoboli et al, 2020. Towards an Innovation-intensive circular economy, FEEM Report

Biomaterials availability

- **Great amount of residues in production: 442 Mt/year**
- **Large potential, partly unexploited/wasted**
- **BUT high demand pressures on some sectors, e.g. wood residues**

Figure 17: Total EU Biomass potential – Current, 2020 & 2030 (Million Tonnes of Oil Equivalent)



Source: Elbersen et al., 2012

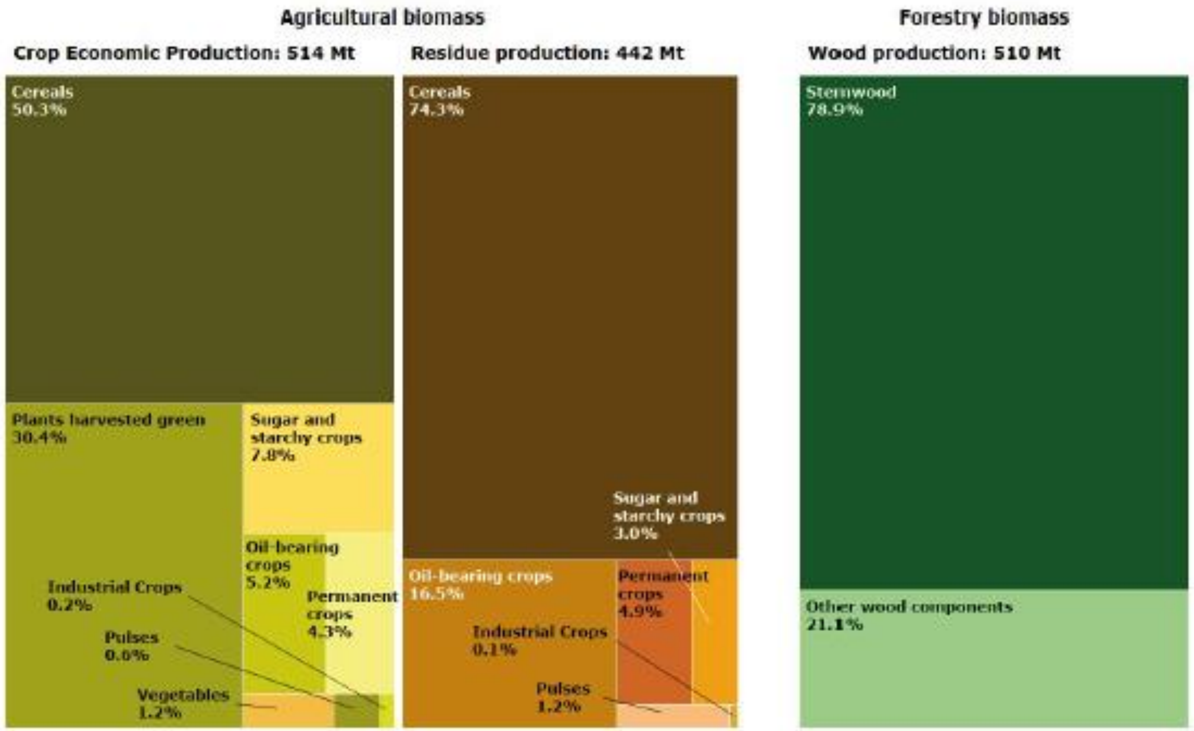
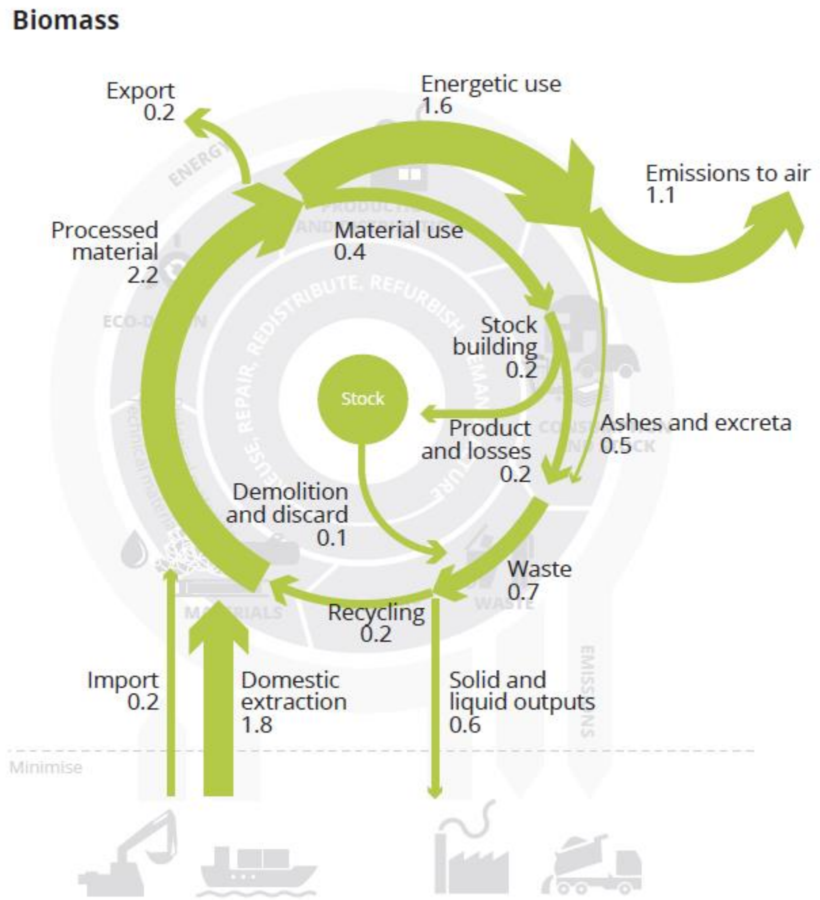


Figure 5. EU-28 annual biomass production from land-based sectors, excluding pastures (10-year average 2006-2015, in megatonnes dry matter). Adapted from Camia et al. (2018). Joint Research Centre Science for Policy Report, doi:10.2760/181536, JRC109869



Biomaterial flows through the EU economy (gigatonnes per year, 2014), Source: EEA 2018

Biomaterials flows EU

- **Too much wasted, or used in low-value processes**
- **Energy use 72% of total uses, and 4 times the material use, with large emissions**
- **Recycling just 28% of waste, and 11% of extraction from nature**
- **Non-recycled biowaste twice the import, and about 38% of domestic extraction**
- **Full biomass recycling/recovery (zero waste/losses) would save values**

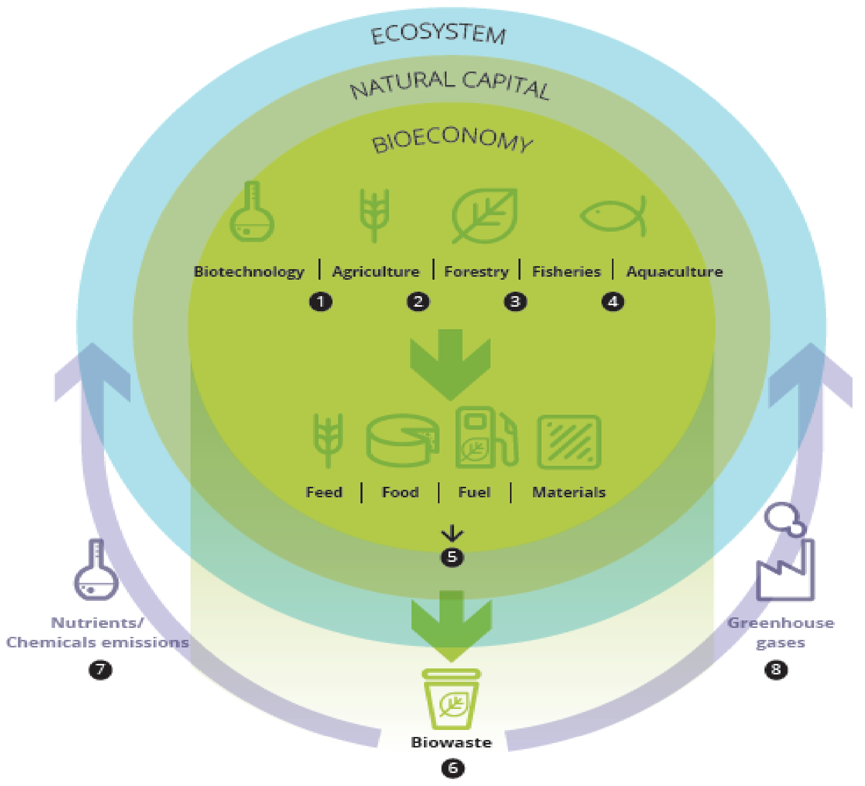
Circular bioeconomy pathways

EEA, 2018, The circular economy and the bioeconomy. Partners in sustainability, EEA Report No 8/2018

- **Pathway 1: Biomaterials to energy**
  - ***Critical issue: Virgin Vs waste feedstocks***
  - ***Critical policies: RES***

- **Pathway 2: Biomaterials to materials/products**
  - ***Critical issue: Innovation-based business models***
  - ***Critical policy: R&D and Innovation***

Figure 5.1 **Pathways and good practices for fostering a circular bioeconomy**



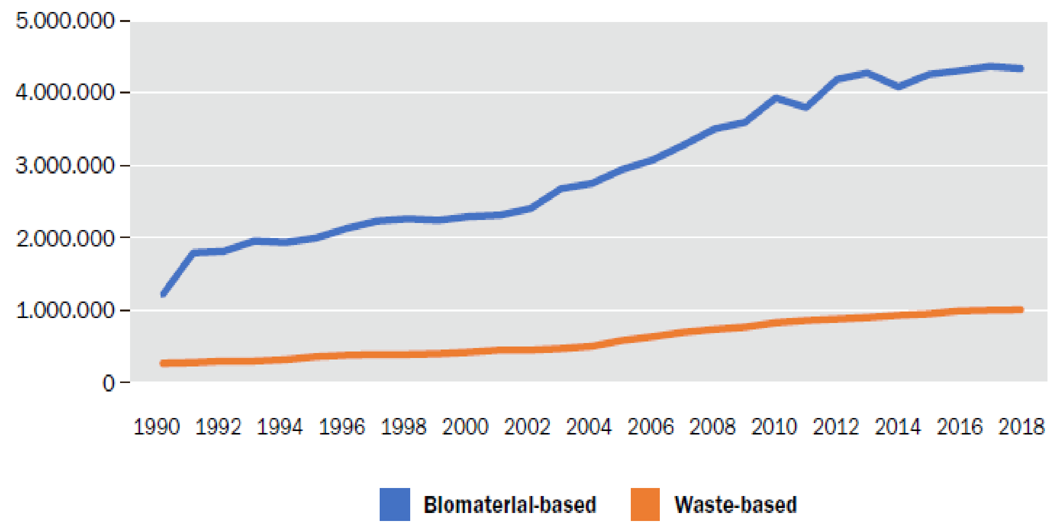
Pathways
1. Replacing fossil-based products
2. Expansion of farmland
3. Intensifying biomass production
4. Aquatic biomass sourcing
5. Changing consumer behaviour
6. Separating biological and technical material cycles
7. Improving nutrient balance
8. Improving energy balance

Bio to energy

Too much RES from virgin biomass (wood)?

Too little RES from 'non-renewable' waste?

Figure 2.4 Domestic production of energy from bio-based and waste-based feedstock, EU27, 1990-2018, Terajoule

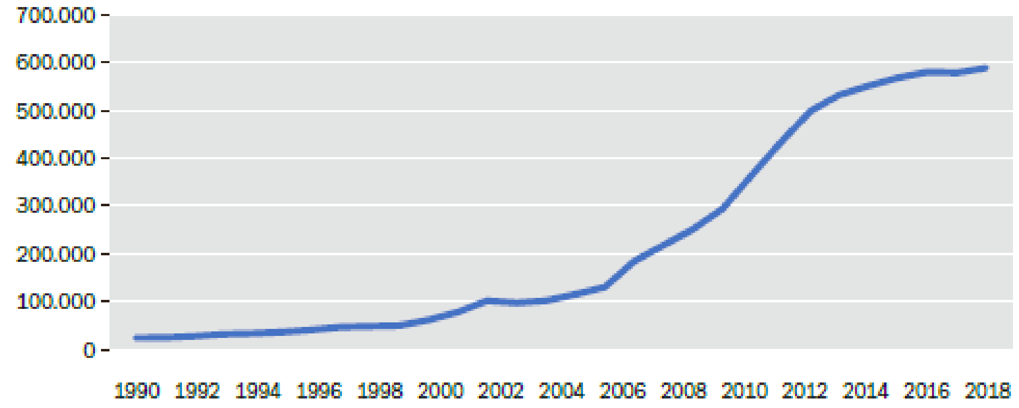


Bio-based feedstock: 'Fuelwood, wood residues and byproducts' and 'Biogases'; Waste-based feedstock: 'Renewable fraction of industrial waste'; 'Industrial waste (non-renewable)'; 'Renewable municipal waste'; 'Non-renewable municipal waste'.

Source: own elaboration on Eurostat data

Biogas/bio-methane good - if not from dedicated crops

Figure 2.9 Biogas production in the EU27, 1990-2019, terajoule



Source: our elaboration on Eurostat data

Integrated business models: e.g. Biorefineries

- Biorefinery plants process **a variety of bio-based raw materials, side streams and waste** in highly integrated and resource-efficient processes
- They provide the opportunity for joining bio- and circular economy principles, especially when using **2nd-generation feedstocks from outside the food and feed sector** (wood and grass, harvest residues and biowaste)

- *BIO-TIC project: by 2030 in the EU there would be a need for 310 biorefineries: 185 2nd generation ethanol, 50 bio-based jet fuel, 30 bio-based chemical building block and 45 bio-based plastics (The bioeconomy enabled - A roadmap to a thriving industrial biotechnology sector in Europe (2015) http://www.industrialbiotech-europe.eu/wp-content/uploads/2015/08/BIO-TIC-roadmap.pdf).*
- *Recent report of the OECD indicates that in order to make the industrial bioeconomy a success, the number of biorefineries, both in the United States and Europe, would have to be increased to between 300 and 400 (OECD (2018), http://dx.doi.org/10.1787/9789264292345-en)*

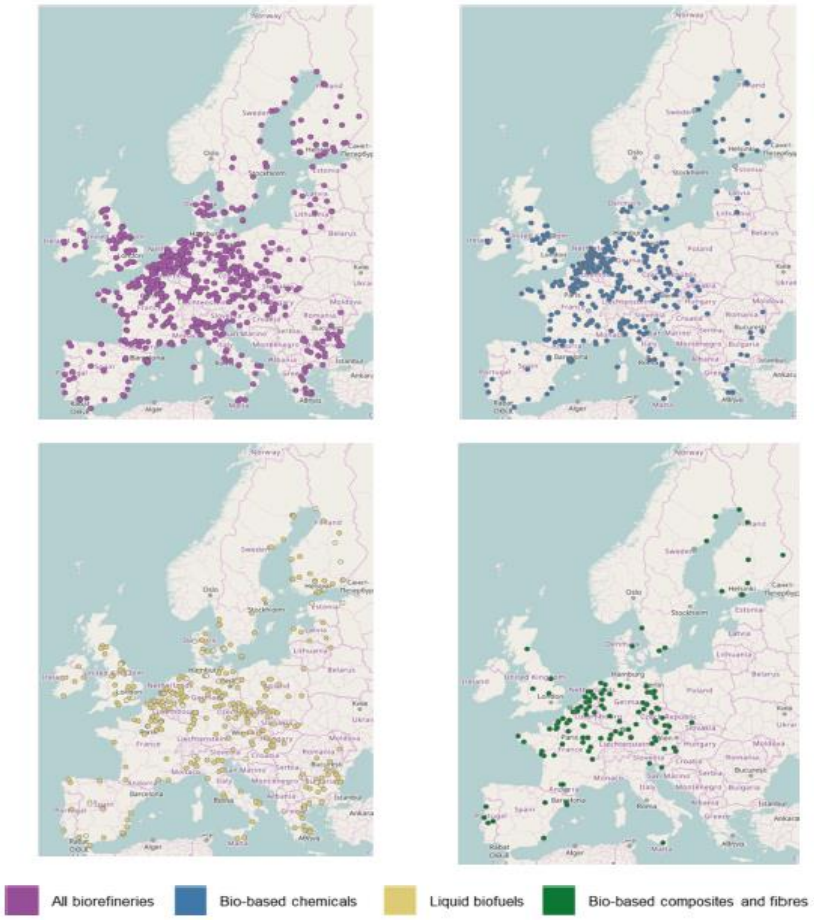


Figure 8. Biorefineries distribution in the EU as of March 2018. Purple dots indicate all biorefineries (803 in total) Blue dots indicate the 507 biorefineries producing bio-based chemicals, yellow dots indicate the 363 biorefineries producing liquid biofuels and the green dots indicate the 141 biorefineries producing bio-based composites and fibres. It has to be noted that some biorefineries produce more than one product category and are thus shown in more than one map. Dots in lighter colour in the three last figures indicate facilities that are currently inactive (but not necessarily as permanent status). Most biorefineries correspond with location of chemical industry clusters and location of ports. Highest density of facilities is in Belgium, Netherlands and some highly industrialised regions of Germany, France and Italy. Source: Parisi, C. 2018. Research Brief on biorefineries distribution in the EU. Joint Research Centre.

Key point

- **Do RES policies push towards contradicting the 'Waste hierarchy' ?**
- **Don't burn value !**
  - ***Max value for virgin biomaterials (residues) in material circularity pathway, not in the energy pathways***
  - ***Integrated business models (e.g. biorefinery concept, local 'industrial metabolism') can optimise the opportunities***

"The meaning of recycling is to save value" **(Robert Ayres)**

Ayres, R.U., 1994. Industrial metabolism: Theory and policy. In: Ayres, R.U., Simonis, U.K. (Eds.), Industrial Metabolism: Restructuring for Sustainable Development. United Nations University Press, Tokyo, pp. 3–20.

Policy issues 3:
Secondary Raw Materials markets

Overcoming barriers to step-up secondary material markets

EEA Report (forthcoming 2022)

Authors: Malin zu Castell-Rudenhausen, Dirk Nelen, Susanna Paleari, Margareta Wahlström, Henning Wilts, Roberto Zoboli

From: IRCrES, SEEDS, VITO, VTT

Table 2.1. Maturity degree of selected SRMs

Keys	GREEN LIGHT= criterion verified	YELLOW LIGHT = criterion partly verified	RED LIGHT = criterion not verified

	Aluminium	Paper	Wood	Glass	Plastics	Biowaste	C&DW	Textiles
High share of supply/demand with respect to total market	YES	YES	Depending on the specific material	YES	High supply, low demand	High supply, low demand	High supply, low demand	High supply, low demand
Enough stable/increasing supply/demand balance	YES	YES	YES	YES	Increasing supply > demand	Increasing supply > demand	Increasing supply > demand	Increasing supply > demand
Open international trade and high tradability	YES	YES	YES	YES, but high transport cost	YES but as waste	Regional markets	Regional markets	YES but as waste
High industrial capacity based on secondary material inputs	YES	YES	YES	YES	Depending on country	Depending on country	Depending on country	Depending on country
Non-policy-driven supply/demand	YES but policies relevant	YES but policies relevant	YES but policies relevant	YES but policies relevant	Policy driven supply as waste	Policy driven supply as waste	Policy driven supply as waste	Policy driven supply as waste
Included in compliance schemes for packaging waste or EPR schemes	YES	YES	YES	YES	YES	NO	NO	Some countries
No competition from energy use	YES	Competition from RES	High competition from E-RES and H-RES	YES	High competition	Competition from biogas / biomethane	YES	YES
Reference international or national prices	YES	YES	YES	YES	YES	NO	NO	NO
'Organised markets' for trading (e.g. futures, etc.)	YES	YES	NO	NO	NO	NO	NO	NO
Sufficient information to both demand and supply actors	YES	YES	YES	YES	YES	NO	NO	NO
Product specifications are standardised	YES	YES	YES	YES	YES	YES	YES/NO	NO
Weak regulatory barriers to use as input	YES	YES	YES	YES	NO	Barriers in some countries	Barriers in some countries	NO

Source: own elaboration on Section 2.2 and background ETC/WMGE reports 2020 and 2021 (unpublished).

- **Seconary Raw Materials as commodities with their own markets**
- **Barriers** to developments of SRM markets: **value chain approach**, different types of barriers identified **by phase** of the SRM value chain (’Product design and making’; ‘SRM supply chain’ - waste availability, waste collection/sorting/preparation, recycling) and SRM demand)

Figure 3.2: ‘Boundary conditions’ (barriers) for improving secondary raw materials production

➢ **Key point: A supply/production bias in waste/recycling policies**

➢ **Product design/making and demand for SRMs the keys to close the loop**

Product design and making: At the stage of product design and making, major barriers arise from the weakness, or the lack of regulatory provisions on design for dismantling and requirements on 'recyclability', even within sectors covered by EPR schemes. From the economic perspective, these barriers arise or persist because the benefits of making products aligned to recyclability are not appropriated by products makers, given that prices of goods do not reward these features of the products. This reinforces the need of regulatory provisions.

Demand of SRM: There are major barriers from the weakness of obligations to use SRM, which is paralleled by the weakness of GPP criteria and their application/enforcement in many countries. In some sectors, there are technical difficulties in introducing recycled materials in product making, unless the product is re-designed or the product is redirected to a different market segment, and in some cases, there is an enduring distrust in final products embodying recycled materials by final consumers. In some markets, the demand of SRM is hindered by their overall costs compared to virgin materials: even when there is large availability of cheap SRMs, their quality can be too low, the supply can be unstable, the logistics can be expensive, the information on SRMs can be limited, the quality of products embodying them can be inferior, thus making their use uneconomical.

Table 4.2: Policy options to remove barriers across the phases of the SRMs value chain

Phase of the value chain	Product design and making (upstream, 'recyclability')	Supply of SRM			Demand of SRM (substitution of primary material or new uses)
Type of barrier mostly addressed by policy measure		In waste input availability/quality	In waste collection/sorting/ dismantling	In waste recycling (manufacturing)	
Removing barriers from (lack of) regulation and legislation	- Improved operationalization (application/enforcement) of DfE provisions (e.g. packaging essential requirements) - GPP targets - Further prohibitions to place on the market not recyclable materials/substances	- Further restrictions of waste exports + better monitoring/enforcement of WSR (to prevent illegal shipments) - Extension of landfill bans - (New/higher) recycling targets (per waste and per material), rewarding quality and not only quantity	- New obligations to separately collect waste	- Development of EU EoW criteria or harmonization of national ones - Development of EU technical specifications/standards for SRMs (clarifying when waste ceases to be waste) - Streamlining/redesign of regulatory framework applying to waste recycling	- Further development of requirements related to recycled content (as the ones in SUP Directive) - GPP targets
Removing barriers from technology and quality				- Development of EU technical specifications/standards for SRMs (to certify the quality of SRMs and the possible applications)	- Development of technical specifications/standards for SRMs (to increase the demand of SRMs) - Better information to consumers on recycled
Removing barriers from economic factors (prices, costs, information, etc.)	- EPR: extension and harmonization of eco-modulation across Member States + extension of EPR (e.g. to textiles) - Supportive framework for rewarding products including DfE (especially DfR) - Improved application of GPP and ecolabel. Better connection to other policy tools.	- Landfill tax to support the application of the waste hierarchy. - Further use of taxation (e.g. tax on non-recycled plastic packaging)	- Further use of economic instruments (e.g. PAYT) to improve separate collection - Extension of EPR (e.g. to textiles) and use of specific EPR schemes (DRS) for some materials	- Extension of EPR (e.g. to textiles) - Networking and information platforms to better connect supply and demand of SRMs	- Use of economic instruments (e.g. reduced VAT) to support products containing recycled materials - Improved application of GPP and ecolabel. Better connection to other policy tools. - Networking and information platforms to better connect supply and demand of SRMs
Removing barriers from competition from energy use		- Better application of circular economy criteria and the Waste Hierarchy			

(Eco)-Innovation and the CE

Level 1: Industrial and innovation policies

Horizon Europe 2021-2027

'Green industrial policy'

Tagliapietra and Veugelers. 2020, https://www.bruegel.org/wp-content/uploads/2020/12/Bruegel_Blueprint_31_Complete_151220.pdf

- Large influence of Decarbonisation and CE strategies
- Large overlap with innova[...] policies and regional development policies
- Smart specialisation, 'eco-systems of innovation'

	Innovation and technology	Investments and deployment	Framewor[...]
EU level	Framework programmes (Horizon Europe);European Innovation Council; Missions; EU Innovation Fund (section 7.3.4)	EU budget and Next Generation EU; European Investment Bank (section 7.3.5); Single market rules (eg green public procurement) (section 7.3.7)	Coordinati[...] national gr[...] industrial p[...] European S[...] RIS3; IPCE[...] (sections 7.[...] 7.3.3);Com[...] policy; Env[...] standards; [...] policy (eg c[...] renewable [...] efficiency t[...] standards; [...] 7.3.6); Deve[...] policy (7.3.[...] Monetary p[...]
National level	Public R&D spending; Intellectual property protection law (at EU level)	Government investment programmes, incentives, subsidies, public procurement, clean energy standards	Consistency of macroeconomic policies with industrial strategy; Climate targets; Environmental standards; Environmental taxation
Regional level	Implementation of public-private partnership in place-based setups (eg university-industry collaborations)	Smart specialisation strategies; Regional Investment budgets; Implementation of EU Cohesion policies	Regulations (such as buildings energy efficiency)

Source: Bruegel.

Pillar II Global challenges:

'Climate, energy, mobility': 15.218 mio/€ (*1.153 mio/€ from NGEU*)

- = 28% of the Pillar
- = 16% of total HE

'Climate, energy, mobility' + 'Food, NR, agriculture': 24.171 mio/€,

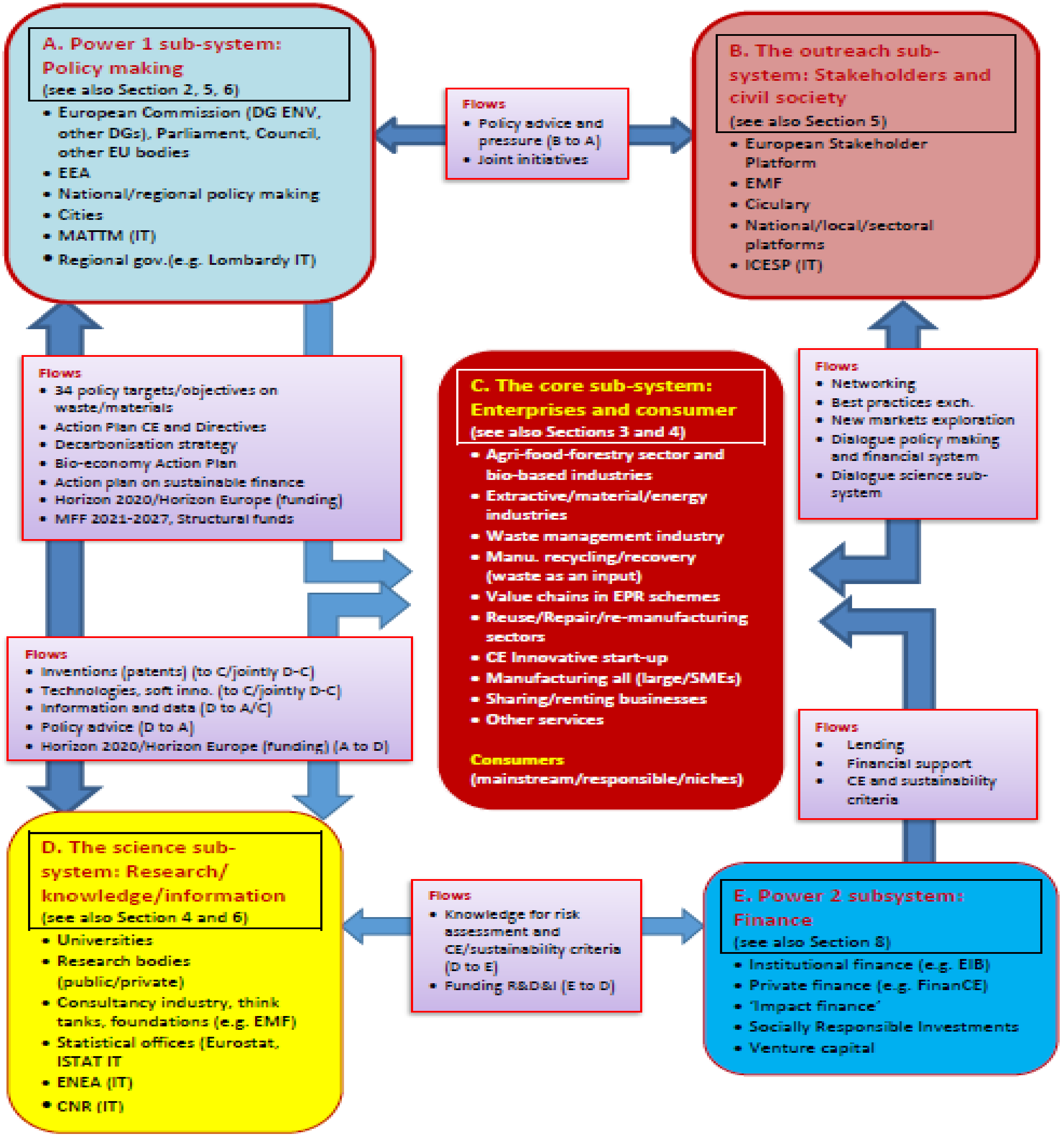
- = 45% of the Pillar
- = 25% of total HE

EIT: 3.155 mio/€ (= 3% total HE)

https://www.agenziacoesione.gov.it/s3-smart-specialisation-strategy/

CE as a 'System of Innovation'

Figure 6.5 A 'circular' sketch of the CE 'System of Innovation' - also based on 'stock taking' in Part 1



Source: own elaboration

Level 2: Circular Business Models

I. Impulse: Capture the need for change from a company perspective for reasons such as changing consumer behaviour and legislation, a possible reduction of resource dependencies and costs and increased motivation for current and future employees. (p.4)

II. Identify: Assessing the environmental and social impact of the current company's business model and of the entire linear value chain. This is achieved by combining the three spheres of sustainability (planet, people and profit)[6] with the magic triangle concept of business models[7]. (p.5)

III. Ideate: Creating ideas for circular ecosystems that go beyond existing solutions with 38 *Circular Ecosystem Patterns* – blueprints from other industries that support organisations in the design of their own circular ecosystem. The blueprints are based on more than 200 mini case studies from different industries. (p.6)

IV. Integrate: Designing a circular ecosystem by consolidating the generated ideas into a circular logic. The *Circular Canvas* provides the structure and flexibility to design and – more importantly – work with the big picture needed to realise the CE. (p.8)

V. Imagine: Expressing the vision and motivation for a circular transformation in one's company, as well as for partners in the circular ecosystem. (p.9)

VI. Incorporate: Approaching the ideal partners and incorporating them into the ecosystem. This aspect is of particular importance for the success of circular solutions because no company can deliver or create all the needed products, services or guidelines alone. (p.10)

VII. Implement: For each company, implementing the ecosystem takes place at the individual business model level. Following the current best practices of de-risking and assumption-based testing for validating new business models, as well as adapting these regarding the specific requirements of the CE, are the key elements to realising the designed ecosystem and reaping the benefits of such a unique offering. (p.10)

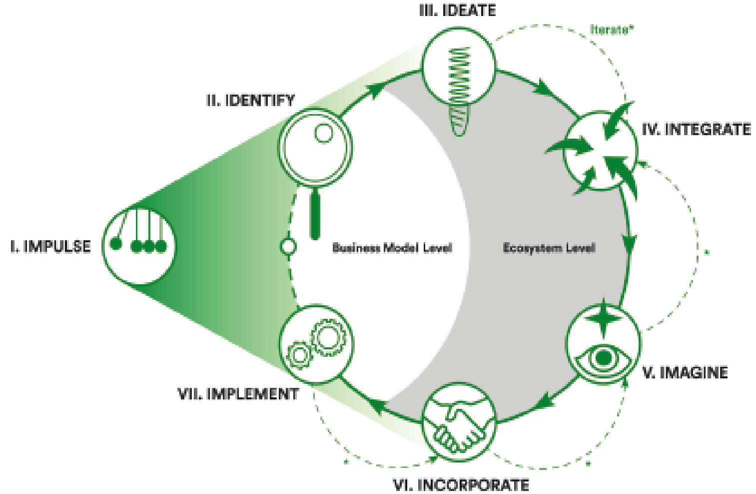


Fig. 1: The seven steps of the Circular Navigator

Sustainable Futures 4 (2022) 100084

Contents lists available at ScienceDirect

Sustainable Futures

journal homepage: www.sciencedirect.com/journal/sustainable-futures

ELSEVIER

A research model for circular business models–Antecedents, moderators, and outcomes

Felicitas Pietrulla*, Karolin Frankenberger

Institute of Management and Strategy, University of St. Gallen, Dufourstrasse 50, 9000 St. Gallen, Switzerland

ARTICLE INFO

Keywords:
Business model innovation
Circular business models
Corporate social responsibility
Dynamic capabilities
Institutional theory
Review

ABSTRACT

The concept of circular business models, defined as firm activities to create and capture value in a circular manner by, for example, extending or continuously reusing product materials, has received increasing attention in management research. The emerging literature, however, lacks theoretical underpinning and empirical findings are not cumulative. Therefore, this article analyzes existing and related research in much detail and presents a comprehensive research model on antecedents, moderators, and outcomes of circular business models. The theories and related research streams considered for the research framework include Institutional Theory, Managerial Cognition, Dynamic Capabilities, Corporate Social Responsibility, Business Model Innovation, and Ecosystems. Gaps within and across the respective research streams concerning circular business models are revealed, and relevant avenues for future research are suggested.

Journal of Industrial and Production Engineering, 2016
Vol. 33, No. 5, 308–320, http://dx.doi.org/10.1080/21681015.2016.1172124

Taylor & Francis
Taylor & Francis Group

Product design and business model strategies for a circular economy

Nancy M. P. Bocken[a,b]*, Ingrid de Pauw[c], Conny Bakker[a] and Bram van der Grinten[c]

[a]*Industrial Design Engineering, Delft University of Technology, Delft, The Netherlands;* [b]*Department of Engineering, Institute for Manufacturing, University of Cambridge, Cambridge, UK;* [c]*IDEAL & Co Explore, Amsterdam, The Netherlands*

(*Received July 2015; revised October 2015; accepted November 2015*)

The transition within business from a linear to a circular economy brings with it a range of practical challenges for companies. The following question is addressed: What are the product design and business model strategies for companies that want to move to a circular economy model? This paper develops a framework of strategies to guide designers and business strategists in the move from a linear to a circular economy. Building on Stahel, the terminology of slowing, closing, and narrowing resource loops is introduced. A list of product design strategies, business model strategies, and examples for key decision-makers in businesses is introduced, to facilitate the move to a circular economy. This framework also opens up a future research agenda for the circular economy.

Keywords: Circular business model; circular design; circularity; sustainability; closed loop

Level 3: CE-innovation (adoption) by firms

- Penetration is slow
- Barriers exist
- Complementarity in EI
- Firm size matters

Research Policy 49 (2020) 103827

Contents lists available at ScienceDirect

Research Policy

journal homepage: www.elsevier.com/locate/respol

Resource efficient eco-innovations for a circular economy: Evidence from EU firms

Giulio Cainelli[a,d], Alessio D'Amato[b,d], Massimiliano Mazzanti[c,d,*]

[a] University of Padova, Italy
[b] University of Rome "Tor Vergata", Italy
[c] University of Ferrara, Italy
[d] SEEDS, Italy - www.sustainability-seeds.org

ARTICLE INFO

Keywords:
Eco-innovations
Circular economy
Firms
Policy
Market demand

ABSTRACT

Innovation adoption and diffusion by firms are key pillars for the EU strategy on resource efficiency and the development of a circular economy. This paper presents new EU evidence regarding the role of environmental policy and green demand drivers to sustain the adoption of resource efficiency-oriented eco-innovations. Using a large cross-section dataset of EU firms and accounting for sample selection and endogeneity, the results strongly support the idea that environmental policy and demand-side factors are both signif
of innovations that promote recycling, reduce waste and decrease the use of mat
relevant piece of new, quantitative-based knowledge, which complements the larg
on sound management and policy strategies for the circular economy.

Micro is beautiful. Determinants of ecological, circular and conventional innovation adoption in micro-firms.

Antonioli D.[1,4], Pronti A.[2,4,*], Zecca E[3,4].

[1]Department of Economics and Management, University of Ferrara, Via Voltapaletto 11, Ferrara (Italy)
[2]Department of International Economics, Institutions and Development, Catholic University of Sacred Heart, Via Necchi 5, Milan (Italy)
[3]Department of Chemical, Pharmaceutical and Agricultural Sciences, University of Ferrara, Via Borsari 46, Ferrara (Italy)
[4]SEEDS, Sustainability Environmental Economics and Dynamic Studies, Via Voltapaletto 11, Ferrara (Italy)
*Corresponding Author: andrea.pronti@unicatt.it

Abstract

In Europe micro-firms contribute significantly to both the economy and environmental impacts on ecosystems. Helping them to become greener and stimulating their innovation towards new sustainable and circular solutions would contribute substantially to European goal of achieving carbon neutrality and environmental sustainability promoted by the European Green Deal and the Next Gen EU programmes. Nevertheless, environmental innovation (EI) of micro-firms is understudied in the literature. In this paper we analyze the main determinants of conventional and EI adoption in micro-firm using an ad-hoc survey developed in Emilia-Romagna (Italy), an important region in terms of innovation, where micro-firms play an important role in the economy. This paper focuses on human capital, training, R&D activities, collaboration activities and environmental culture within the firm as main determinants of innovation adoption, in addition to other standard drivers and barriers of innovation adoption studied in the literature. Moreover, we compare the innovation adoption of micro-firms with SMEs. Our results highlight differences between the determinants of EI and conventional innovations adoption and important heterogeneities between micro-firms and SMEs in innovation adoption strategies.

Keywords: Micro-firms, Circular-Innovation, Eco-Innovation, Circular Economy, Training, Employees

Received: 8 March 2020 | Revised: 23 October 2020 | Accepted: 6 November 2020

DOI: 10.1002/bse.2688

RESEARCH ARTICLE

Business Strategy and the Environment WILEY

On the contribution of eco-innovation features to a circular economy: A microlevel quantitative approach

Christoph P. Kiefer[1] | Pablo del Río[1] | Javier Carrillo-Hermosilla[2]

[1]Institute for Public Policies and Goods (IPP), Consejo Superior de Investigaciones Científicas (CSIC), Madrid, Spain
[2]Department of Economics and Business and Banco Santander Chair of Corporate Social Responsibility, Universidad de Alcalá (UAH), Alcalá de Henares, Spain

Correspondence
Pablo del Río, Institute for Public Policies and Goods (IPP), Consejo Superior de Investigaciones Científicas (CSIC), C/Albasanz 26-28, 28037 Madrid, Spain.
Email: pablo.delrio@csic.es

Abstract

The circular economy (CE) and eco-innovation (EI) are two concepts deemed instrumental in achieving a sustainable transition. They have been proposed in the academic literature and by practitioners and have acquired very high public policy relevance, being endorsed by policymakers and ultimately leading to regulations supporting them. It has been argued that both concepts are compatible and interrelated and that EI is instrumental in achieving the CE. However, little is known about how different EI features contribute to the CE at the microlevel. This article tries to cover this gap. Its aim is to assess and quantify the causal relationship between different EI features and the CE with the help of a unique dataset of small- and medium-sized firms in Spain and an econometric analysis. Our results show that only systemic EIs contribute to a global CE, whereas other EI types such as component additions or small changes in existing production processes could even be barriers to high levels of circularity. It is found out that technological novelty is not relevant for reaching the CE. The results support the understanding of how EIs enable a transition to the CE. Care should be taken not to promote incremental EIs that do not only achieve low (or no) circularity but that effectively lock-in the economic system in solutions that entail a barrier to the achievement of high-level circularity.

KEYWORDS
circular economy, eco-innovation, small- and medium-sized firms, Spain, transition

Level 3: CE-innovation (adoption) by firms

Journal of Cleaner Production 247 (2020) 119648
Contents lists available at ScienceDirect
Journal of Cleaner Production
journal homepage: www.elsevier.com/locate/jclepro

The progressive adoption of a circular economy by businesses for cleaner production: An approach from a regional study in Spain

Alfonso Aranda-Usón [a], Pilar Portillo-Tarragona [b], Sabina Scarpellini [a, *], Fernando Llena-Macarulla [b]

[a] University of Zaragoza, Department of Accounting and Finance and CIRCE Research Institute, Spain
[b] University of Zaragoza, Department of Accounting and Finance, Spain

A R T I C L E I N F O

Article history:
Received 27 April 2019
Received in revised form
7 December 2019
Accepted 9 December 2019
Available online 10 December 2019

Handling editor: Prof. Jiri Jaromir Klemeš

Keywords:
Cleaner production
Circular economy
Environmental management accounting
Sustainability accounting
Regional planning

A B S T R A C T

The literature on the circular economy at the micro-level has mainly focused on the analysis of the circular business model and implementation of different circular-related practices, but the process of adoption by businesses of the circular economy is still under investigation. Therefore, through a study in the region of Aragón, Spain, the main circular economy-related activities implemented by a sample of 52 businesses are classified into four levels as an approach to the change process that firms can undergo to adopt the circular economy. In summary, it can be stated that circular economy-related activities are being introduced by businesses progressively, from a minor activity to a greater number of activities, but that these activities do not respond to the incremental closure of material loops within the circular economy framework. The applied indicators enhance the knowledge on the environmental management accounting applied to the CE for the reporting and the relations with stakeholders. In addition, the measurement of the introduction of the circular economy in different businesses is relevant for practitioners and for policy makers, in response to the institutional initiatives for the promotion of the circular economy at the territorial level.

Received: 12 November 2021 | Revised: 16 February 2022 | Accepted: 26 February 2022
DOI: 10.1002/bse.3046

RESEARCH ARTICLE

Business Strategy and the Environment
WILEY

Sustainable production: The economic returns of circular economy practices

Davide Antonioli[1,2] | Claudia Ghisetti[2,3] | Massimiliano Mazzanti[1,2] | Francesco Nicolli[2,4]

[1]Department of Economics and Management, University of Ferrara and SEEDS—Centre for Sustainability, Environmental Economics and Dynamics Studies, Ferrara, Italy
[2]Fondazione Eni Enrico Mattei (FEEM), Milan, Italy
[3]Università degli Studi di Milano Bicocca, Milan, Italy
[4]Department of Economics and Management, University of Ferrara, Ferrara, Italy

Correspondence
Francesco Nicolli, Department of Economics and Management, University of Ferrara, Via Voltapaletto 11, 44121, Ferrara, Italy.
Email: francesco.nicolli@unife.it

Abstract
Assessing the economic consequences of sustainable pro
reducing negative environmental externalities is crucial for
the increasing interest and awareness experienced in recent
assessment is one of the goals of the current work, which tri
ical evidence on the economic returns of circular economy p
vious literature on the underlying determinants of greener p
are stated to differ from standard technological innovations
knowledge and an environmental externality. Using an orig
mately 3000 Italian manufacturing firms, we provide evidenc
innovations related to the circular economy concept and e
short run. The evidence shows that in the short run, it is dif
gains from circular economy related innovations when tak
for Small and medium-sized enterprises (SMEs), who may
returns.

KEYWORDS
circular economy, economic return, firm competitiveness, sustainabl

Received: 21 September 2020 | Revised: 8 October 2021 |
DOI: 10.1002/bse.2940

SPECIAL ISSUE ARTICLE

Industry 4.0 technologies and circular economy: The mediating role of supply chain integration

Eleonora Di Maria | Valentina De Marchi | Ambra Galeazzo

Department of Economics and Management 'Marco Fanno', University of Padova, Padova, Italy

Correspondence
Valentina De Marchi, Department of Economics and Management 'Marco Fanno', University of Padova, 33 via del Santo, 35123, Padova, Italy.
Email: valentina.demarchi@unipd.it

Abstract
There is a great expectation that Industry 4.0 technologies will enable better circular economy (CE) results at firms. However, it is unclear how these technologies might contribute to CE. We hypothesize that Industry 4.0 technologies are positively related to the level of integration among actors along the supply chain and within the firm supply chain integration (SCI), which, in turn, explains superior CE results. By employing partial least square structural equation models on original survey data based on a sample of more than 1200 Italian manufacturing firms and almost 200 adopters, we find that disentangling for the type of technologies is essential to understanding both their direct and indirect role toward CE. Smart manufacturing technologies have a stronger impact on CE outcomes than data processing technologies; the mediating effect of SCI is verified for the former but not for the latter type, questioning the possibility for those technologies to support sustained CE performance in the long run.

KEYWORDS
big data, circular economy, digital technologies, robots, smart manufacturing, supply chain integration

- Training is relevant
- Industry 4.0 matters
- Policies matter as driver
- Uncertain returns

Main conclusions

- **Micro opportunities Vs changing value chains Vs ‘substitution economy’**
- **CE policy-driven ….. so far**
  - CE policies can reshape industries (plastics)
  - CE policies can be displaced by other policies (RES)
  - CE policies can be insufficient to close the loop (SRM)
- **Difference between idealisations on Circular Business Models and real-world CE (eco-) innovation**

Open issue

- **How much structural is the energy and material crisis?**
- **'Self-sufficiency'** the new mantra (part of re-shoring, de-globalisation trends)

- **Effect 1: Incentives to circularity from markets/prices**: Can they overcome policy insufficiencies?
- **Effect 2: Pressures on domestic (non-waste) resources**: Adverse effects via NEXUS in the bioeconomy?