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TESIS DOCTORAL:

JUST ENERGY TRANSITIONS TO LOW CARBON ECONOMIES: COAL MINING AREAS AND WELFARE POLICIES

Presentada por Pablo García García para optar al grado de Doctor por la Universidad de Valladolid

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LIST OF ABBREVIATIONS AND COUNTRY CODES

AEE	Asociación Empresarial Eólica (Wind Business Association)
AL	Available land
al.	Others
Avebiom	Asociación Española de Valorización Energética de la Biomasa (Spanish Association for Energy Valorisation of Biomass)
AW	Available qualified workers
B	Biomass
Bac.	Baccalaureate
BAU	Business As Usual
BDEW	Bundesverband der Energie- und Wasserwirtschaft (German Association of Energy and Water Industries)
C	Concurrence matrix
CARF	Carbon footprint
CBI	Conservation Basic Income
CBI+S	Conservation Basic Income and Services
CBS	Conservation Basic Services
CES	Constant Elasticity of Substitution
CGE	Computable General Equilibrium (model)
CIEMAT	Centro de Investigaciones Energéticas, Medioambientales y Tecnológicas (Centre of Energy, Environmental, and Technological Research)
CLD	Causal Loop Diagram
CO_2	Carbon dioxide
COMF	Potential competition for public funding
COVID	Coronavirus disease
CTJ	Convenio de Transición Justa (Spanish Agreement of Just Transition)
Cum. Aff. W.	Cumulative Affected Workers
Decommodif.	Decommodification
DEGURBA	Degree of urbanisation
DMC	Domestic Material Consumption
DTU	Danmarks Tekniske Universitet (Tecnical University of Denmark)
e.g.	Exempli gratia (for example)
EPI	Environmental Performance Index
EPPE	Environmental public expenditure
EPS	Environmental Policy Stringency
EQF	European Qualifications Framework
ES	Environmental State
ESS	European Social Survey
EU	European Union
EUR	Euro currency
GDP	Gross Domestic Product
GHG	Greenhouse Gases
GIS	Geographic Information Systems
GU	Graduates in universities
GV	Graduates in vocational training

i.e.	Id est (that is)
IAE	Impuesto sobre Actividades Económicas (Spanish tax on economic activities)
IAM	Integrated Assessment Model
IBI	Impuesto sobre Bienes Inmuebles (Spanish property tax)
IEA	International Energy Agency
ILO	International Labour Organisation
INE	Instituto Nacional de Estadística (Spanish National Institute of Statistics)
IO	Input-Output
IOA	Input-Output Analysis
IOTs	Input-Output Tables
IPCC	Intergovernmental Panel on Climate Change
IRENA	International Renewable Energy Agency
ISTAS	Instituto Sindical de Trabajo Ambiente y Salud (Spanish Trade Union Institute of Work, Environment and Health)
Km^2	Square kilometre
KWh	Kilowatt-hour
LOCE	Local public expenditure
LOCR	Local public revenues
LTUN	Long-term unemployment rate
M	Millions
m^2	Square metre
MATF	Material footprint
MITECO	Ministerio para la Transición Ecológica y Reto Demográfico (Spanish Ministry of Ecological Transition and Demographic Challenge)
MLP	Multi-Level Perspective
MRIO	Multi Regional Input-Output
Mt	Megatonne
MW	Megawatt
n	Employment factor
	Observations (sampling)
N	Direct labour demand
NN	Net employment
NR	Jobs at risk
OCAW	Oil, Chemical and Atomic Workers International Union
OECD	Organisation for Economic Co-operation and Development
p	Standard power
	Educated working-age population
PCI	Projects of Common Interest
PES	Payment for Ecosystem Services
PPF	Production Possibility Frontier
PPP	Purchasing Power Parity
PV	Photovoltaic
r	Land requirements
R&D	Research and Development
REE	Red Eléctrica de España (Spanish National Electricity Network)
RENE	Renewable energy share

RES	Renewable Energy Sources
RL	Required land
RRMW	Recycling rate of municipal waste
SARS-CoV-2	Severe Acute Respiratory Syndrome Coronavirus 2
SAU	Sociedad Anónima Unipersonal (Spanish single-shareholder corporation)
SCEN	Scenario
SD	System Dynamics
SDGs	Sustainable Development Goals
Sec.	Secondary Education
SEPE	Servicio Público de Empleo Estatal (Spanish Public Employment Service)
SFD	Stocks and Flows Diagram
SINC	Income share
SNM	Strategic Niche Management
STA	Spatial Transition Analysis
Strat.	Stratification
SW	Sustainable Welfare
SWOT	Strengths, Weaknesses, Opportunities and Threats
T	Tonnes
t	time
UBI	Universal Basic Income
UBS	Universal Basic Services
ULe	University of León
UN	United Nations
	Unemployment rate
UNED	Universidad Nacional de Educación a Distancia (Spanish National University of Distance Education)
Uneq	Unequal
UNU-WIDER	United Nations University World Institute for Development Economics Research
USD	United States Dollar currency
Voc.	Vocational training
W	Wind density
	Wind
W. A. Pop.	Working-age population
WEFF	Welfare effort
WS	Welfare States

Country codes follow ISO Alpha-2 nomenclature:

AT	Austria
BE	Belgium
CH	Switzerland
CZ	Czech Republic
DE	Germany
DK	Denmark
EE	Estonia
ES	Spain
FI	Finland
FR	France
GB	United Kingdom of Great Britain and Northern Ireland
GR	Greece
HU	Hungary
IE	Ireland
IS	Iceland
IT	Italy
NL	The Netherlands
NO	Norway
PL	Poland
PT	Portugal
RO	Romania
SE	Sweden
SI	Slovenia
SK	Slovakia
US	United States of America

ABSTRACT

This thesis explores the socioeconomic effects of energy transitions towards renewable sources, their implications for justice, and potential courses of political action based on the Welfare States to provide just energy transitions.

Initially, we explicit the goals of the research and the hypotheses under study and disclose the theoretical and methodological frameworks that support our work. Afterwards, we present the literature review findings, which determine the potential effects of renewable technologies on employment and income distribution and delimit gaps to propose a research agenda. Most studies find a positive, yet small, effect on employment levels and some negative effects associated with the difficulties in the reconversion of some jobs and the scarce labour mobility of certain sociodemographic profiles. Concerning income, analyses conclude negative effects through rising electricity prices and regressive subsidies. Nonetheless, there is a margin to enrich the status of the literature. We suggest as high priority tasks furthering the availability and complexity of studies about income distribution, with a focus on the need and design for fiscal countermeasures to compensate for regressivity, widening the methods applied to employment, introducing degrowth scenarios, varying the number and typology of cases, and observing a gender dimension. Additional tasks comprise the exploration of systemic tools, broadening the scope of models, and introducing subjective perceptions in quantitative techniques to orientate decision-making and assessments.

Subsequently, we dive into the Leonese case study, a restructuring from coal mining and thermoelectric production of electricity to wind, solar, and biomass power. We estimate the consequences of such a shift for employment levels and land requirements through a systemic modelling exercise inspired by System Dynamics. Additionally, we show the gaps between the theoretical framework of just energy transitions, the findings of the review, and the current political proposals for León. The model indicates that the preferential installation of the current renewable tenders in the province compensates for the jobs at risk in the short term. Notwithstanding, renewable sources cannot keep the population in the areas, so the restructuring should be complemented by alternative activities, such as rural tourism, agroindustry, and a "silver economy" around care. Furthermore, the model detects relevant shares of required land for the installation of renewable technologies and sensitive trade-offs between the promotion of employment and the modification of land uses. These insights could enhance the current processes of just transition, which show shortcomings in their concept and design, diagnosis, and mechanisms of public participation.

Finally, we increase the scale in our approach to analyse the capacity of Welfare States to ease the transition through the hypothesis of eco-social synergy, which results rejected under a comparable methodology that seeks to avoid past shortcomings in the literature through the joint application of Ward's hierarchical clustering algorithms in squared Euclidean distances and Thorndike's criterium of optimality in a sample of 23 European countries from 2008 to 2016. The results illustrate that the paradigmatic Nordic countries fail to mobilise local resources sustainably and are responsible for the worst environmental performances. Parallelly, Liberal and Conservative regimes tend to display better environmental results, although worse social situations. However, there is not a clear correspondence between the typologies of welfare regimes, the social dimension, and the environmental status. Despite the rejection, some traits of Social-democratic regimes motivate a discussion about Sustainable Welfare and its downscaling to local levels. Specifically, there is a relevant potential in the implementation of Conservation Basic Incomes and Services.

This thesis contributes to the current state-of-the-art and political processes on multiple lines. First, the literature review offers an overview for researchers interested in engaging on this topic or updating their knowledge, as well as for policymakers to consider the most recurrent effects of their political initiatives. Second, the Leonese case promotes research about neglected local rural scales and addresses the specific situation of the area under study, which has not received attention from academia. Meaningful parallelisms can be established for comparative and prescriptive purposes with other declining fossil-dependent areas in developed countries under intense destruction of industrial networks in recent decades. Third, the modelling is an easy exercise to potentially promote mutual understanding among stakeholders and reinforce procedural justice in the processes of just energy transition. We additionally show that data shortages are an avoidable problem under our methodological proposal. Four, the literature review and the simulation exercise illustrate the negative effects of the transition to renewable energy sources and contrast with the ambition of political plans. Finally, we shed light on the functioning of the hypothesis of eco-social synergy by screening and discussing indicators, applying a methodology to reduce conditioning assumptions, and pointing to precise courses of action to implement a potentially facilitating public welfare system.

Keywords: Energy transition, renewable energy, socioeconomic impact, justice, Welfare State.

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Chapter 1

INTRODUCTION

1.1. Motivations of this research

Societies are struggling with a twofold global crisis. On the one hand, there is natural deterioration. Regarding resources, the situation is characterised by the peak oil phenomenon (Campbell & Laherrere, 1998; Murphy & Hall, 2011), which supposes the decline of the extraction of this fuel and the subsequent challenge for fossil-dependent societies while they face the emergence of physical limits to the predominant model of production and consumption (Meadows, Randers, & Meadows, 2004; Randers, 2012). The phenomenon is a sign of the rise of energy scarcities and the end of an economic expansion supported by low energy prices (Carpintero & Riechmann, 2013). Concerning residues, the current scenario is defined by climate change because of the atmospheric saturation through damaging emissions (IEA, 2018; IPCC, 2014). Humanity surpassed such ecological limits as climate change, the biodiversity extinction rate, and the nitrogen cycle for human uses more than a decade ago (Rockström et al., 2009). On the other hand, there is social deterioration. Poverty, inequality, and discrimination are widespread (Vicente Perdiz, Rubio Sanz, & Decimavilla Herrero, 2010) and have been exacerbated by such events as the financial collapse in 2008 and the COVID pandemic. Environmental deterioration and socioeconomic problems are the two main challenges of the century (Poschen, 2017).

To face these challenges, governments are promoting socio-ecological transitions to sustainable paradigms. Ecological values are progressively perceived by individuals as reinforcing values, as proves the proliferation of social movements that demand reforms and the momentum of the environment among the main worries of electors. While this transition is a wide concept, we are focusing on the particularities of the energy transition, which showcases the leading role among the panoply of transitions to sustainability given the intense interaction between energy, the environment, and the progress of society. Political agendas have been increasingly adopting a notion that is not new for the dynamics of the social-environmental conjunction but is experiencing a revival and adapting to the present statu quo and the discourses and proposals across the political spectrum, activisms, and academia: just energy transitions.

Just energy transitions are being pictured as the means to tackle jointly environmental ravages and socioeconomic deterioration and represent a vast field of study. On the side of the social consequences of the transition, there is a need to contribute

to the theoretical framing of the notion and shed light on the precise effects on labour and income distribution. As observed during the last years in multiple conferences, seminars, and research pieces, there is an omnipresent worry among researchers in the field of just transitions. This concern is the translation of such an abstract concept as "justice" into practice. Although justice is a secular topic that has inspired rivers of ink to flow across varied disciplines, the application of the idea to the ongoing energy transitions has left a blank space in the literature to explore. Subsequently, as the conceptualisation of justice in the context of energy transitions has been enriched recently, notably since the introduction of the Sustainable Development Goals (SDGs), the main concern has moved to the methodological field. Once the application of justice has been determined in the theoretical sphere, doubts emerge around the empirical application of justice. There are developing discussions around the measurement of the notion of justice, its inclusion in quantitative techniques, and the simplifications and assumptions that are introduced in the leap between theory and practice. Parallelly, there is a concern about the role of scholars in the process and how research must provide scientifically orientated political agendas. In brief, as heard in one of the first conferences in which this research was presented, there is a fear of "never touching the ground" in this incipient, abstract, complex, and conflicting field that demands urgent action.

Fossil-dependent areas in developed countries can offer significant insights into socioeconomics and justice in energy transitions due to the decline that they have experienced in recent years and the pessimistic options that are available for them in the future. These fossil-dependent areas can be widely found across Spain. However, a case presents a special relevance, due to both its significance for the national and regional situation (Ministry of Ecological Transition and Demographic Challenge, 2020g; Pérez Díaz & María-Tomé Gil, 2020) and its closeness to our experience: the Leonese mining and thermoelectric areas in the West and North of the province.

The Leonese economy has been historically associated with the mining of coal and the electric generation based on it. Mining started to proliferate in the 18th and 19th centuries in El Bierzo and in the 20th century in the area of Montaña Central, where the first thermoelectric plant in the region of Castile and León was established in 1919. The arrival of the railway, the increased demand for coal during World War I, protectionism and the oil crises drove the Leonese mining to reach its historical maximum by the mid-1980s. Since then, mining has started a process of accelerated decline caused by the differential profitability of imported coal since the entry of Spain into the European Union (EU) and the successive climate agreements, the lowering of prices of renewable technologies and the rising costs of emissions rights of greenhouse gases (GHG).

This decline has caused firings, remunerated leaves, and early retirements, and has forced processes of migration, depopulation, ageing, dependency, and territorial

polarisation. Likewise, it has had an important environmental effect derived from the abandonment of installations and exploitations and a fiscal effect based on the reduction of local public revenues through property taxes (IBI in Spanish) and taxes over economic activities (IAE in Spanish), which has motivated the loss of public services. In this context, previous attempts to promote alternative activities in the areas resulted unsuccessfully.

Even if the Leonese energy transition began in the 1990s, the Spanish Ministry of Ecological Transition and Demographic Challenge, MITECO in Spanish, is currently leading processes of just transition in Montaña Central-La Robla (Ministry of Ecological Transition and Demographic Challenge, 2020l, 2020e) and El Bierzo-Laciana, with four priority areas: Fabero-Sil (Ministry of Ecological Transition and Demographic Challenge, 2020c, 2020j), Bierzo Alto (Ministry of Ecological Transition and Demographic Challenge, 2020a, 2020h), Laciana-Alto Sil (Ministry of Ecological Transition and Demographic Challenge, 2020d, 2020k), and Cubillos del Sil-Ponferrada (Ministry of Ecological Transition and Demographic Challenge, 2020b, 2020i), therefore congregating five of the seven active interventions at a regional scale. These interventions under the specific umbrella of just energy transition coincided with the beginning of this research.

As empirical works have gradually begun to find some undesirable social consequences of the energy transitions, not only in Spain, but in other European and non-European contexts, wide social sectors claim for parallel public intervention to redirect the restructuring and, therefore, new questions have emerged on the side of the policies. Specifically, there is a need to determine how governments can compensate for the negative impacts of the transition while potentiating the positive outcomes. In this regard, an increasing number of research outcomes are asking to define the role of current Welfare States (WS) to face the transition and explore emerging fields such as Sustainable Welfare (SW).

The most notable discussion in this regard revolves around the inherent traits of Social-democratic welfare regimes in the sense of Esping-Andersen (1990) to streamline the establishment of a state that is socially and environmentally conscious, the Green State, Eco State or Environmental State (ES). This notion is central to the unfolding process of just energy transition, although it appears more frequently attached to the study of transitions towards sustainability in general, and commonly receives the denomination "hypothesis of synergy" (Fritz & Koch, 2019; Koch & Fritz, 2014; Koch, Gullberg, Schoyen, & Hvinden, 2016). According to the hypothesis of synergy, the levels of decommodification and low social stratification offered by Social-democratic regimes lay the ground for a more effective transition in social and environmental terms. If accepted, well-known public welfare policies that have been active since the 1970s and in which

current governments have acquired relevant experience could represent an immediate solution to the negative impacts and side-effects of the restructuring. If rejected, more research is needed to determine the shaping of precise political actions.

The theorisations of this hypothesis were formulated in the literature some years ago (Dryzek, 2008; Gough et al., 2008; Meadowcroft, 2008). However, the empirical proposals to test it are more recent (Fritz & Koch, 2019; Jakobsson, Muttarak, & Schoyen, 2018; Koch & Fritz, 2014; Otto & Gugushvili, 2020; Zimmermann & Graziano, 2020). As we dived into the theoretical and empirical discussion, we discovered the existence of contradicting results and the underlying need to reinforce the methodologies used to test them. The discussions around the hypothesis and their implications for the field of just energy transitions are solely in a preliminary stage in which much remains to be said.

The work that is presented in the following Chapters embraces these matters, doubts, and discussions. It seeks to contribute to the conceptualisation of just energy transitions, translation of justice into the empirical study, determination of social effects, and definition of margins of policy action through welfare regimes.

1.2. Goals

The main goal of this research is to determine the socioeconomic effects of energy transitions to RES (Renewable Energy Sources) and suggest potential courses of action to ease the process through welfare regimes, considering the insights offered by Ecological Economics about the social-environmental conjunction. In compliance with this main goal, this research pays special attention to two aspects:

First, the conclusions of previous incipient studies and reports about justice in energy transitions (Balibar, 2017; D'Alessandro, Luzzati, & Morroni, 2010; Fernandes, 2017; Fragkos & Paroussos, 2018; ILO, 2018; Just Transition Research Collaborative, 2018; Kemfert, 2017; Kjaer, 2013; Markandya, Arto, González-Eguino, & Román, 2016; Solomon & Krishna, 2011; Williams & Doyon, 2019) and the cases of energy restructuring and transition that are closer to the author's experience: the Leonese mining and thermoelectric areas.

Second, the role played by the public sector in the management of the process of transition, by minimising the negative social impacts and maximising the positive impacts through public policies, particularly welfare policies (Bouzarovski & Tirado Herrero, 2017; Westholm & Beland Lindahl, 2012).

To foster the main goal, this research proposes three secondary goals:

First, to revise the literature about the socioeconomic effects of the transitions to sustainable energy models and the framework of just transitions (Gambhir, Green, & Pearson, 2018; Heffron & McCauley, 2018; ILO, 2015; Jasanoff, 2018; Newell &

Mulvaney, 2013; Poschen, 2017; UNRISD, 2019) . The revision must determine how the concept has been studied by researchers addressing the effects on labour and income, the methods that have been employed, and the results reached. Subsequently, the analysis must determine to what extent the empirical results are conditioned by the applied methodologies, and whether the studies are consistent or not with each other. Finally, it must assess these efforts and detect their strengths and weaknesses to propose a research agenda.

Second, to analyse the most recent proposals for a just transition of the areas under study (Ministry of Ecological Transition and Demographic Challenge, 2020f; Spanish Institute of Just Transition, 2021) and determine the strengths and weaknesses of public plans, as well as to offer quantitative insights into the development of the restructuring to find the priorities of future political agendas and stakeholders' action. This determination of the socioeconomic impacts of the energy transition in the terms described in the main goal seeks to contribute to the discussion about the translation of the idea of justice into the practical ground and the determination of the precise effects of the process.

Third, to explore the capability of welfare regimes to ease the transition and provide a sustainable and just future (Bäckstrand & Kronsell, 2015; Koch, 2019; Koch & Fritz, 2014; Meadowcroft, 2008), i.e., revisit and test the hypothesis of synergy, so public welfare policies can be aligned with the best strategies to satisfy this aim.

These goals are jointly meaningful for this research because of four circumstances:

First, the current proposals for an energy transition have originated certain reticence due to the potential socioeconomic consequences of the process. This is especially observed in areas like León, with high specialisation and dependence on the exploitation of fossil sources that have rapidly declined during the past decades, consequently concentrating the harshest socioeconomic deterioration. It is, therefore, necessary to jointly analyse the environmental concerns and socioeconomic deterioration in the same theoretical-empirical corpus.

Second, there is a call to provide more accurate visions that focus on the socioeconomic challenges, restrictions, and dilemmas of the transition, both in the scholarly and political discussion, consequently detecting and broadening new horizons in the frame of public policies and welfare.

Third, proposals of transition gather highly ambitious political goals. There is a need for studies to assess critically the plausibility of these plans, particularly regarding the socioeconomic restrictions that they are facing.

Finally, this proposal contributes to promoting an underdeveloped area of the literature, the conjunction of energy transitions and social effects, and offers innovative insights into the case of León, derived from the incursion of this thesis on a scale that previous research has neglected: the local rural level.

In summary, our proposal aspires to jointly apply quantitative techniques and qualitative assessments orientated by the literature to assess justice in the energy transition, as well as to dive into the theoretical discussion to further adjusted political agendas.

1.3. Hypotheses

Once we have determined our goals, we are able to disclose the hypothesis that this research work aims at testing.

Hypothesis 1

The energy transition is considered an opportunity to provide jobs. The proliferation of RES requires economic activities such as construction, installation, manufacturing, operation, and maintenance to the extent of seeing RES as more labour-intensive sources than traditional ones.

As the energy transition progress, considering the framework theorised by the ILO (Figure 1-7), we ought to expect a displacement of investments from conventional to green sectors, a subsequent labour-demanding deployment of infrastructures, an injection of subsidies to fund these technologies, as well as education programmes to facilitate the transition. In consequence, the demand for workers is expected to increase in the energy sector. A positive impact in the energy sector is likely to increase disposable income and arouse a sensation of economic security among workers, with a subsequent positive impact on the rest of the economy. Meanwhile, negotiation would serve to improve the quality of jobs, including the level of wages. As income increases, the revenues that the public sector can collect also grow so that governments can tackle inequalities and poverty with greater supporting resources under the form of defensive policies.

Provided that the transition to RES is expected to have a positive impact, it is considered a relevant opportunity for declining fossil-dependent areas in developed countries under intense processes of deindustrialisation, which have experienced a sharp socioeconomic erosion during the past decades. Although some alternatives have been formulated for them in diverse contexts, the most immediate option is a reconversion towards RES. This option is adequate, given that the needed energy infrastructures to transport energy are still in place and human capital is highly specialised in technical skills because of past experiences in mining and thermoelectric production.

Coherently with this vision, we hypothesise that *the impact of the energy transition on employment and income is positive for the energy sector (direct) and this positive result echoes in the rest of the economy (indirect and induced).*

Hypothesis 2

In the process of transition, WS are increasingly seen as necessary to compensate for the potential negative effects and boost positive impacts, hence reinforcing justice. Social-democratic regimes, i.e., those with high decommodification and low stratification, are thought to be in an advantageous position to perform a just transition. On the one hand, decommodification alleviates environmental pressure by providing independence from markets, so that individuals can have a prosperous life without incurring environmentally damaging activities. On the other hand, a low stratification enables individuals to share power and increase democratic practices, so that procedural justice is regarded.

Therefore, we propose the hypothesis of eco-social synergy as our second statement to test: *Social-democratic welfare regimes display better environmental performance and are closer to the notion of ES, hence reinforcing the just transition*.

1.4. Theoretical framework

This Section discloses the theoretical framework in which this thesis is rooted. It consists of three parts: Ecological Economics, sustainability transitions and just energy transitions, and Welfare States and the environment.

1.4.1. Ecological Economics

Ecology and Economy share a common root: οἶκος, the "house". Both disciplines are, therefore, related and solely differentiated by λόγος and νόμος, i.e., the "logic" or "reasoning" (understood as a field or discipline) and the "rules" or "norms" (understood as the administration), respectively. Etymologically, Ecology is "the study of the house" and Economics is "the management of the house", hence understanding "house" as the commonplace for humanity: the world as a whole or a region of it (Costanza, 2019).

This etymological parallelism, nonetheless, has remained far from the course of action regarding the separate historical evolution of Ecology and Economics in recent times. Modern Economics has pictured the economic functioning and the evolution of societies as a subject that is unaffiliated with the environmental dimension, or even superior to it. In recent times, Economics has been closer to the Aristotelian censure of chrematistics than to "the management of the house".

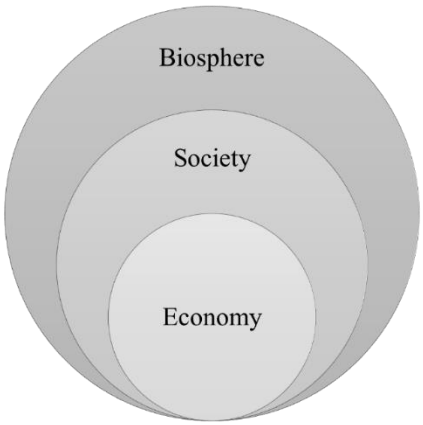
As a result of the evolution of disciplines, both converged again to reclaim their common origin. This convergence materialised in the field of Ecological Economics, whose precedents can be detected in the 17th century and proper origins are traced to the

late 19th and early 20th centuries. At that moment, Geddes, Soddy, and Popper-Lynkeus, none of them economists, supported a biophysical approach to the economy (Martinez-Alier & Schlüpmann, 1987). More recent, advanced works in the 1960s and 1970s mark its more commonly considered appearance, although Martinez-Alier (2015) delays the consideration of Ecological Economics as a school until the 1980s when the first books, journals, and journal issues with a concordant title appeared.

Particularly in this period, Boulding proposed a transition from "frontier" to "spaceship" Economics, i.e., from a social paradigm of welfare based on material consumption to a paradigm in which welfare has decoupled from the material dimension (Boulding, 1966). Daly subsequently assimilated Economics into a life science (Daly, 1968) and jointly with Boulding and the first authors in this alternative tradition, some economists and some ecologists, suggested a shift from markets towards biophysics. Furthermore, Daly proposed a steady state in an early stage (Daly, 1973). Diving into the issue, Georgescu-Roegen (Carpintero Redondo, 2006), influenced by the studies on human energy uses by Lotka, examined the law of entropy and the economic process to conclude that, from a thermodynamical point of view, unlimited growth is unsustainable (Georgescu-Roegen, 1971) so degrowth is prescriptive (Georgescu-Roegen, 1979), and wrote critiques to the incipient trends in the field (Georgescu-Roegen, 1977). Parallel works by institutionalists, such as Kapp and von Ciriacy-Wantrup, also contributed to shaping the emerging school.

Due to the diversity of its founders, Costanza (2019) describes Ecological Economics as a "meta paradigm". It recognises the complexity of the social-environmental conjunction, and thus, proposes holistic and pluralistic discussions. Similarly, Ecological Economics is defined as a transdisciplinary field of study that considers the economy as a subsystem of a larger, limited and global ecosystem, hence inferior or subordinate to it, so that the economy is an open system embedded in the ecosystem (Carpintero, 2009; Martinez-Alier, 2015), as the canonical representation of the discipline reflects (Figure 1-1) (Passet, 1979).

Figure 1-1 The conception of the economy from the viewpoint of Ecological Economics



Source: Own elaboration based on Passet (1979).

Passet's (1979) notion is of uttermost relevance for this framework, whose argumentation provides a key point. The reproduction of each sphere in Figure 1-1 is dependent on the others, so the economy and society cannot survive without the support of nature. Passet emphasises the order of relations so that the elements of the economic domain belong to the biosphere and follow its principles, but the biosphere does not belong to the economic sphere nor follow its rules. Hence, two major implications can be derived.

First, the existence of limits imposed by superior spheres. The evolution of the economy and society is hierarchically constrained by the scope of the biosphere. The economy cannot surpass it and must adhere to the principles that govern it.

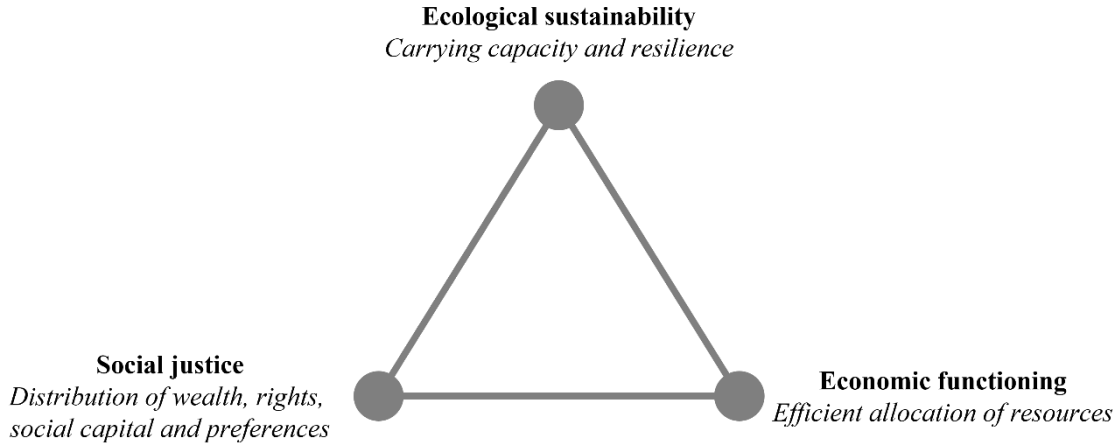
Second, a violation of the limits of the biosphere triggers an ecological crisis. To foster a sustainable relation between economy and biosphere, the subsystem ought to observe its metabolism, i.e., how it takes energy and materials from the superior system. The adequate coexistence suggests using renewable sources and closing material cycles through recycling. In consequence, the energy transition as an area of the broader transition to sustainability is in essence a transition from one socio-metabolic regime to another (Krausmann, Fischer-Kowalski, Schandl, & Eisenmenger, 2008), i.e., a socio-ecological transition (Fischer-Kowalski et al., 2012). The latter can be defined as the change from a model of interaction between societies and natural systems (socio-ecological regime) to another model that faces social and environmental deterioration (Fischer-Kowalski & Haberl, 2007).

This vision, in combination with Daly's proposal for a steady state or Georgescu-Roegen's insights into the unfeasibility of unlimited growth based on entropy, contrasted with the economic theory predominant in this period: Keynesianism, i.e., a focus on short-

term and continuous, frequently irreversible, expansions through demand. However, a common interest motivated a progressive conciliation of ideas to the extent of setting up a Macroeconomic corpus without growth, including Keynesian postulates (Daly & Farley, 2010; Holt, Pressman, & Spash, 2009; Jackson, 2009). Such progress without economic expansion is interlinked with the notion illustrated by Easterlin's Paradox, remarkably known in the Economics of Happiness (Easterlin, 1974; Easterlin, McVey, Switek, Sawangfa, & Zweig, 2010). In practice, this conception of happiness or prosperity leads to promoting a shift towards less intense and productive jobs, universal incomes, and restoration of ecosystems, as Jackson (2009) recommended to the Government of the United Kingdom, thus claiming for the greater intervention of the public sector regarding welfare.

According to Costanza (2019), the goals of the school are threefold and hierarchical. First, to determine the extent of human activities and reconcile them with the ecological limits of the biosphere. Second, to promote a just distribution of resources. And third, to subsequently allocate resources, marketed or not, in an efficient way provided the status of the biosphere and the social situation of justice (Figure 1-2). From the viewpoint of the cited author, nature and society are similar as they are subject to limits in a context of uncertainty and complexity, and both belong to the domain of sustainability, with biophysical and justice limits respectively.

Figure 1-2 Complex interrelations in Ecological Economics



Source: Own elaboration based on Costanza (2019).

A distinctive feature of Ecological Economics as a meta paradigm, open and transdisciplinary, beyond initial disputes on its focus is incommensurability (Carpintero Redondo, 1999; Martinez-Alier, Munda, & O'Neill, 1998). Although monetary valuations are sometimes used, notably for communicative purposes with other schools of thought or individuals that are external to Economics, there is a widespread consensus

about the unsuitability of prices to make future decisions (Vatn & Bromley, 1994). Assessments with a strict preference for physical valuations and indexes of sustainability that catch the social metabolism (material and energy flows, ecological footprints, inter alia) replace prices and market equilibriums (Martinez-Alier, 2015), while participation, deliberation or willingness to pay methods replace cost-benefit analysis (Costanza, 2019; Munda, 2008; Spash, 2011; Zografos & Howarth, 2008).

As far as the physical valuation is concerned, Ecological Economics points to the need for spatial analysis of human activity and its guidance in the allocation of resources. Spatial analysis is aimed at determining the dynamics, in combination with time and subject to uncertainty, of ecosystem services in the satisfaction of individual and collective preferences, as well as in the provision of well-being (Costanza, 2019). In this regard, and following the participatory approach beyond commensurability, modelling techniques that can represent the spatial-temporal liaisons between the complex coevolution of the economy and the ecosystem have found a relevant place in the school. The introduction of spatial analysis in economic studies is major progress. Traditionally, space has been a foreign domain for Economics, in a reductionist and artificial attempt to stem the tide. To "manage the house", we ought to know and consider the location and spatial challenges to which resources are subject.

The transversality and versatility of Ecological Economics, incommensurability, an underlying interest for space, and remarkably, the limits derived from the superior hierarchy of the biosphere and the need for sustainability to conciliate the spheres of the seminal conceptions of Ecological Economics through socio-ecological transitions based on metabolic shifts, constitute the ground in which this thesis is rooted and represent a structure to lead our focus: just energy transitions.

1.4.2. Sustainability transitions and just energy transitions

Given the social-environmental status and the reconciliation of disciplines that study our common house, during the past few decades there has been growing interest in the notion of socio-ecological transition, as determined above. The energy concerns that are linked to the current socio-ecological regime, which fuel our motivation to perform this research as commented in Section 1.1, suggest the need to focus on the subsequent energy transition to a low carbon paradigm.

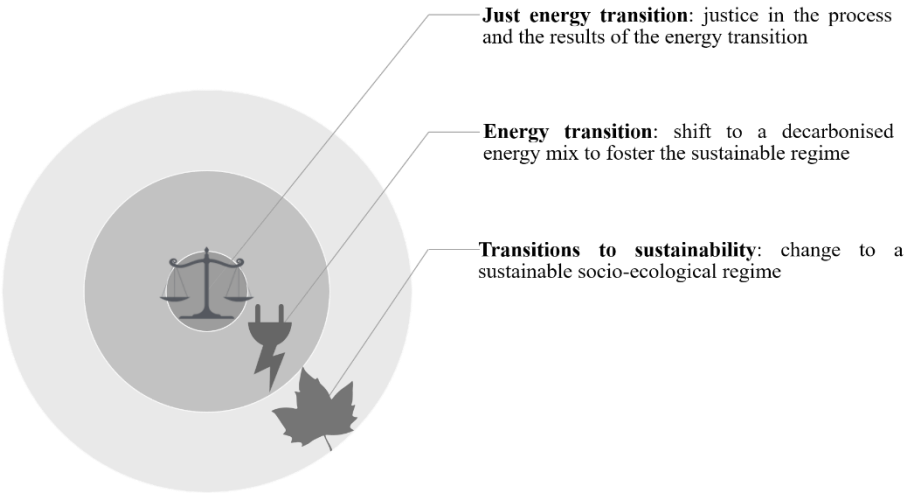
Such an energy transition implies changes in energy generation, distribution, storage, and usage (IPCC, 2011, 2019), but also a complex set of interconnected social, political and economic rearrangements (Miller, Iles, & Jones, 2013). In the convergence of energy transitions and socioeconomic concerns the concept of a "just energy transition" arises. Even though this idea has a considerable grounding in contemporary history, it has experienced a revival and evolution in recent years (ILO, 2015; Just Transition Research

Collaborative, 2018) motivated by the said dual crisis (Markandya et al., 2016; Renner, Sweeney, & Kubit, 2008) and the uncertainty about the social effects of the energy transition, notably regarding labour and income distribution.

Historically, while past energy transitions were involuntary, the present transition is a complex policy-led process with time goals (European Commission, 2019; UN, 2015a, 2015b). A set of public policies is aimed at fostering the sustainable energy transition while, at the same time, managing the resulting consequences for natural and human systems (Newell & Mulvaney, 2013), since it is thought that markets cannot be trusted (Fay, Hallegatte, & Vogt-Schilb, 2013) to compensate for the negative side effects.

The concept of "just energy transition", in the spotlight of this thesis due to the energy concerns associated with the current twofold crisis, is a part of broader concepts that we have to address first (Figure 1-3). Three layers can be distinguished. In the first layer, there is the idea of a socio-ecological transition. A second layer would be the concept of the energy transition. In a third and last layer, we can find the notion of just energy transition, which arises as one of the diverse possibilities of shaping an energy transition.

Figure 1-3 Conceptualisation of a just energy transition



Source: Own elaboration.

In the first layer, the transitions to a sustainable regime are a broad category that alludes to a process of shift from one socio-ecological regime to a more sustainable regime (Behrens et al., 2014; Cambridge Econometrics, 2013; Carpintero & Riechmann, 2013; Fouquet, 2016; Haberl, Fischer-Kowalski, Krausmann, Martinez-Alier, & Winiwarter, 2011; Rockström et al., 2009; Sempere Carreras, 2014).

In the second layer, energy transitions, as one of the multiple dimensions of a socio-ecological transition to sustainability (European Commission, 2012; OECD, 2012a; Sovacool, 2016; Sovacool & Geels, 2016; UNEP, 2011), imply a process of shift that affects the generation, distribution, storage and use of energy (IPCC, 2011, 2019) and causes rearrangements in policies, economies and societies (Miller et al., 2013). There are diverse formal definitions that consider different elements in energy transitions (Sovacool, 2016).

On the one hand, some notions of "energy transition" focus on energy sources and technologies, sometimes connoting a mere change in fuels and in the technologies used to exploit them (Hirsh & Jones, 2014; Miller, Richter, & O'Leary, 2015), specifying that the transition refers to an economic system (Fouquet & Pearson, 2012), an energy system (Grubler, Wilson, & Nemet, 2016), or to the timing from the introduction of a new source to the moment when it reaches a notable market share (Smil, 2010a).

On the other hand, energy transitions are more frequently pictured as complex phenomena made up of a set of changes affecting resources, services and agents (O'Connor, 2010). These phenomena are defined as co-evolution processes referenced to socio-technical systems, or regimes in general (Haxeltine et al., 2008), implying changes in their tangible elements (such as technologies, infrastructures and markets), in their agents and networks and the foundation of their socio-technical system (Geels, 2004; Geels & Schot, 2010; Sovacool & Geels, 2016).

In any case, the essence of the transition, as understood today, is not the shift in the energy mix, but the attempt to prevent the escalation of tropospheric temperature. Accordingly, it implies the decarbonisation of the energy supply on a global scale (Smil, 2016).

In the third layer, the concept of "just energy transition" adds the concerns of justice and equity to the previous one (Gambhir et al., 2018; ILO, 2015), even if little attention has traditionally been paid to energy justice (Evensen, Demski, Becker, & Pidgeon, 2018) in comparison with energy sustainability.

The evolution of the concept has been as follows (Figure 1-4):

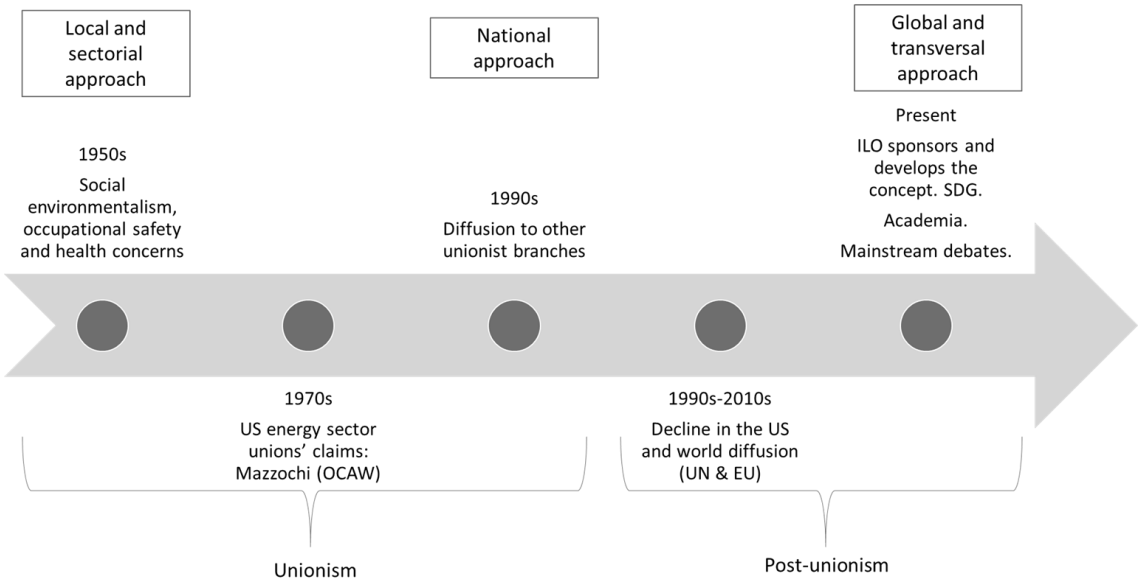
The roots of the current notion of "just energy transition" are in the union movements of the North American energy sector in the 1970s. The unionist Tony Mazzochi was, to the best of our knowledge, the first contributor to shape the concept of "just transition" on behalf of the struggle of the Oil, Chemical and Atomic Workers International Union (OCAW) to grant propitious labour conditions to the employees of several refineries (Just Transition Research Collaborative, 2018).

The original concept served to unify the social environmentalism of the 1950s and elements of occupational health and safety that influenced environmentalist claims in the next two decades, closely linked to climate and environmental justice (Schlosberg & Collins, 2014).

The diffusion of the concept occurred in the 1990s when the notion was adapted to other unionist branches and a Just Transition Alliance was set up. In the last two decades, while the use of the concept has declined in the American context, the idea has been considered enriching abroad; in fact, it has been significantly present in the United Nations (UN) and the EU.

Over four decades, it has transcended its original scope to become a global idea that has been included in the mainstream debate, especially linked to the energy transition. The main efforts to study and analyse the concept are currently being carried out in the framework of the ILO, which has sponsored it in the SDGs (ILO, 2018; Poschen, 2017).

Figure 1-4 Just energy transition evolution timeline



Source: Own elaboration.

Conceptually, the call for a just energy transition is connected to the concept of "energy justice", which is disaggregated into distributional, procedural and recognition justice (Chapman, McLellan, & Tezuka, 2018; Finley-Brook & Holloman, 2016; Jenkins, McCauley, Heffron, Stephan, & Rehner, 2016; McCauley, Heffron, Stephan, & Jenkins, 2013; Williams & Doyon, 2019). Distributional justice refers to how societies share the positive and negative effects of energy policies. Procedural justice stresses the importance of the just participation of all stakeholders in the process of policy development. Recognition justice involves the delimitation of adversely affected collectives. Revisited conceptions are also introducing the final notion of restorative justice, to consider the

compensations to those individuals whose rights have been vulnerated because of the transition (Galvin, 2020). Although justice in energy transitions is frequently understood as a final result, justice must also be seen as a process (Steenbergen & Schipper, 2017).

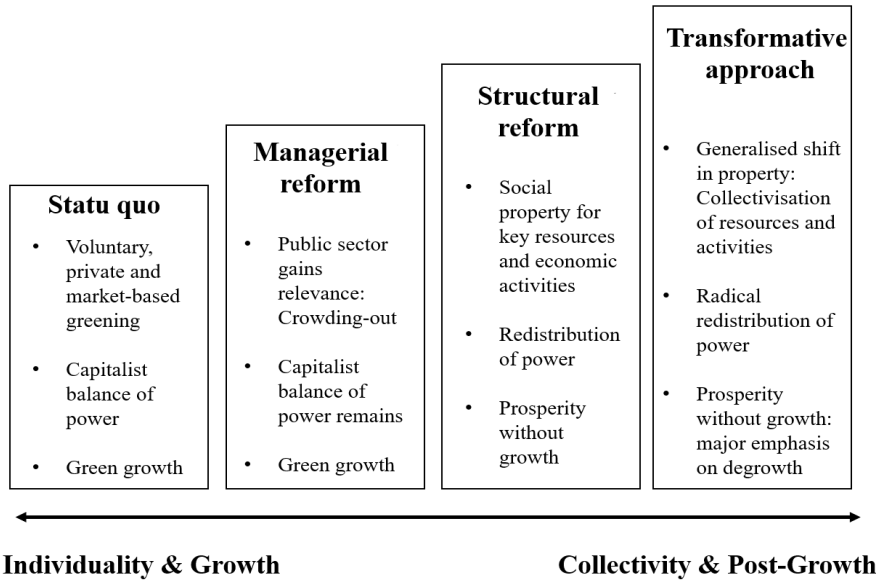
Due to its wide diffusion, the concept has been analysed through different approaches, of which four can be emphasised, as observed by the Just Transition Research Collaborative (Just Transition Research Collaborative, 2018):

- The "statu quo approaches" consider a voluntary, private, and market-based greening of the system that maintains its capitalist traits.
- The "managerial reform approaches", in which the public sector assumes higher importance, without changing the inherent capitalist balance of power.
- The "structural reform approaches" highlight the need for a redistribution of power and the existence of social property for key assets and activities.
- The "transformative approaches" support a radical change of the economic system, as it is assumed to be responsible for the negative socio-economic and environmental outputs.

International organisations tend to position themselves between the managerial and structural approaches, while unions and non-governmental organisations are closer to the transformative approach.

These approaches involve two different views regarding economic growth. On the one hand, some authors consider that economic growth is a desirable output of the transition because 1) the cost of decreasing the emissions responsible for climate change is insignificant in comparison with the cost that an economic system will have to face if climate change worsens (Ekins, 2002; N. Stern, 2007); and 2) the cost of decreasing the emissions is lower than the benefits of the transition towards a green paradigm (Bowen & Fankhauser, 2011). On the other hand, other authors consider that the transition requires a dramatic change in our societies, away from the growth paradigm, and instead support a "post-growth perspective" or a "prosperity without growth" approach, which implies controlled degrowth in the use of energy and materials (Jackson, 2009; Kallis, Kerschner, & Martinez-Alier, 2012; Martínez-Alier, Pascual, Vivien, & Zaccai, 2010; Odum & Odum, 2006; Victor, 2008) (see how both dimensions are related in Figure 1-5).

Figure 1-5 Approaches to the concept of just energy transition



Source: Own elaboration.

To illustrate these approaches, we have turned to the discourse and the theoretical developments of the ILO, the main contributor and sponsor of the concept nowadays. The ILO (Poschen, 2017) considers that the transition offers three opportunities and three challenges (Table 1-1).

Table 1-1 Opportunities and challenges of a just energy transition in the ILO framework

Opportunities	Challenges
Creation of net employment	Socioeconomic restructuring
Double dividend	Ecologisation
Economic growth via investment	Increasing resources productivity
Improvement of labour quality	Higher automatisation
Higher wages via higher competence and specialisation	Variation in the sectoral composition of employment
Permanent and full-time jobs	Implication of employees and social stakeholders
Higher labour protection and better working conditions	Small labour mobility
Highlighted sectors	Difficulties for small businesses
Agriculture: absorption of new workers in better conditions	Adaptation to climate change
Recycling: job regularisation, female labour, higher intensity and wages	Extreme weather conditions and their multidimensional consequences
Construction: regularisation, competence and health safety	Poor harvests
Social inclusion	Scarcity of drinking water
Reduction of poverty and access to affordable non-pollutant energy	Migrations
Gender equality	Compensation of regressive political effects
Enhancement of local communities via environmental payments	Higher energy prices and negative effects on income distribution

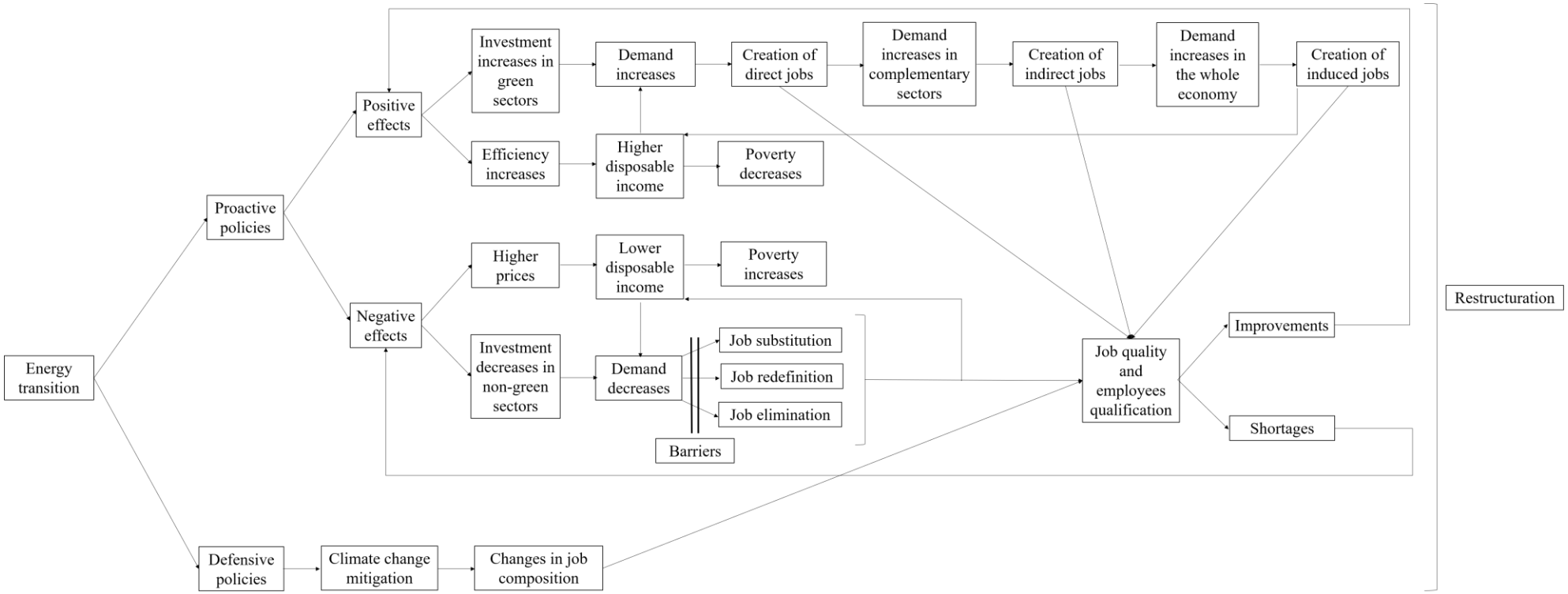
Source: Own elaboration.

The trigger of the transition is the joint effect of demand and investment shifts towards green sectors and the subsequent displacement of resources from non-green activities, mainly guided and propitiated by public policies. These changes will cause a parallel creation and destruction of direct jobs and propagate through supply chains and income variations affecting the whole economy, therefore creating and destroying indirect and induced jobs. These effects have also been observed by other organisations (IEA, IRENA, & REN21, 2018; OECD, 2012b). The net balance of jobs would be a result of demand levels, investment, trade flows and labour elasticity. The adjustment difficulties could come from unexpected job losses, the age and geographical identification of employees, the absence of nearby alternatives, and the shortcoming of political programmes. It must be emphasised that, from this perspective, not only must gross and net effects on employment be considered, but also job quality, employee skills, and gender equality, a key worry for the ILO (ILO, 2018).

Concerning income, more ecological goods and services could lead to higher prices, and thus to a smaller amount of available income to spend on other goods and services. Inversely, more profitable investments and efficiency could boost demand in subsequent periods, through a shift from energy demand, with low elasticity, to non-energetic goods and services with a higher elasticity (Poschen, 2017). The outcome in resource consumption and Gross Domestic Product (GDP) is a priori undetermined (see the antagonist forces operating in Figures 1-6 and 1-7).

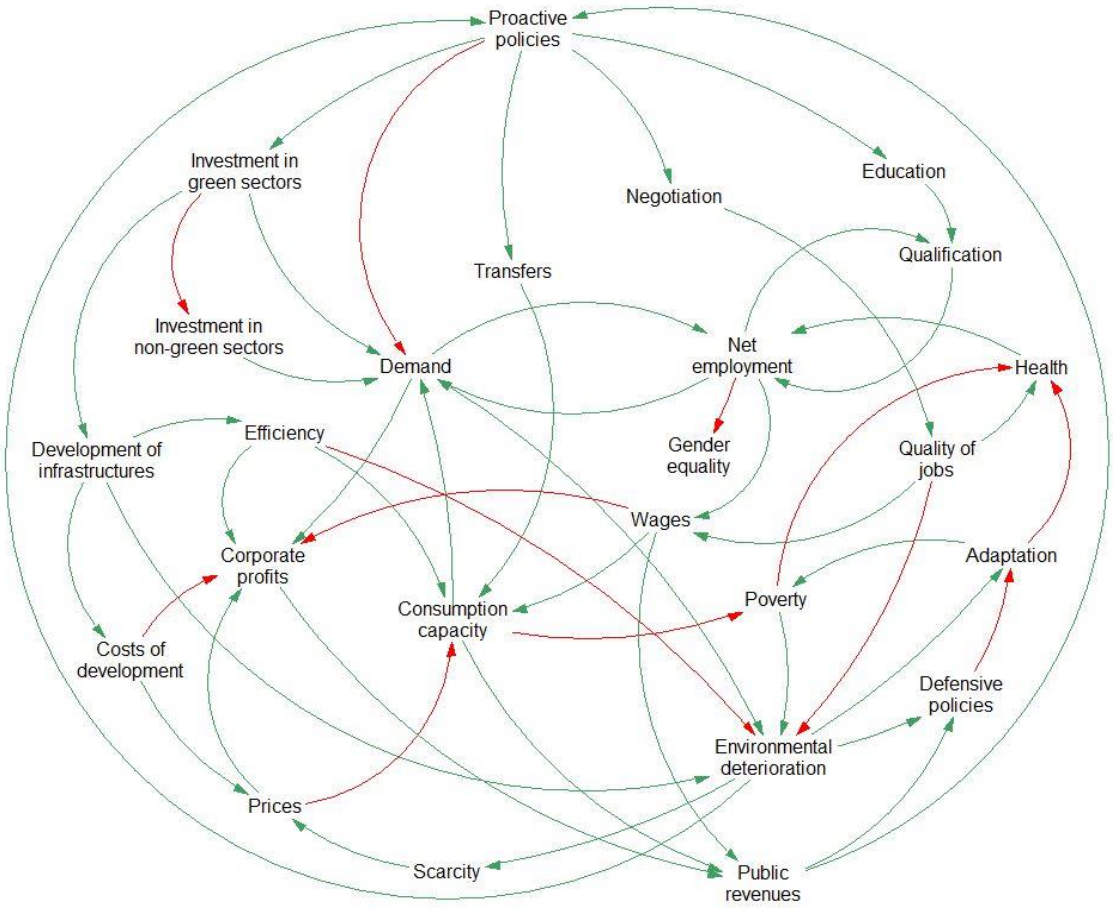
This combination in the ILO framework of a strong public sector with a positive narrative about economic growth, but with some nuances of post-growth, can be identified as a managerial reform close to some elements of the structural reformative approach.

Figure 1-6 Theoretical effects of energy transition on labour and income from the ILO perspective



Source: Own elaboration.

Figure 1-7 Diagram of influences based on the theorisations of the ILO: direct relations in green and indirect relations in red



Source: Own elaboration.

As a concluding point to clarify our theoretical framework, we propose a definition by combining the previous partial definitions and the elements revised in this Section.

A "just energy transition towards a low carbon economy" can be defined as a long-term technological and socio-economic process of structural shift (Iychettira, Hakvoort, & Linares, 2017; Miller et al., 2013; O'Connor, 2010) that affects the generation, distribution, storage and use of energy (Hirsh & Jones, 2014; IPCC, 2011; Miller et al., 2015) and causes rearrangements at the micro (innovation), meso (social networks, rules and technical elements) and macro (exogenous environment) levels (Geels, 2004; Geels & Schot, 2010; Haxeltine et al., 2008; Solomon & Krishna, 2011; Sovacool & Geels, 2016), while also ensuring that the desired socioeconomic functions can be accomplished through decarbonised and renewable means of energy production and consumption (Smil, 2005, 2016), safeguarding social justice, equity and welfare.

From a practical perspective, the transition is a public matter of instrument choice (to foster the substitution of energy sources) and instrument change (to adapt the policy

scheme in coherence with the multidimensional challenges that must be faced) (UNU-WIDER, 2017).

Scholars have not agreed upon the principles of how to analyse a just energy transition, apart from the need to contrast the net effects of all alternatives (Jasanoff, 2018). Notwithstanding, a group of demands and features for a just energy transition are recurrent. They can be called the "must-have" principles of a just energy transition:

- The transition must be flexible enough to cope with uncertainty and social complexity (Smil, 2005).
- The costs derived from the transition are not the only matter to contemplate. The collectives that have barriers to accessing the benefits of the transition, generally low-income households (Damette, Delacote, & Del Lo, 2018; McCabe, Pojani, & Broese van Groenou, 2018), must have their barriers removed and benefit in equal conditions.
- Policies must consider and respect the rights of local communities and solve the historical injustices caused by the diversity of perspectives among stakeholders. Scholars propose community-based participatory decision-making and increasing cross-border activism supported by research (Finley-Brook & Holloman, 2016).
- The transition policies must ensure qualified jobs and human resources, enable retraining, focus on education, health and creativity, provide certainty to industries in transition and facilitate new businesses (Sievers, Breitschopf, Pfaff, & Schaffer, 2019).
- Policies must be consistent, driven by a long-term vision and fuelled by cooperation between stakeholders, with special emphasis on the participation of workers (Gambhir et al., 2018).

Beyond this conceptualisation, both notional and historical, the recent impulse by the ILO, and the incipient methodological debates that we observed at the beginning of this research work, in 2018, many issues must be addressed to contribute to enabling just energy transitions worldwide. Especial attention deserves the correction of negative effects and the potentiation of the positive ones, particularly regarding the role of current welfare structures in the process.

1.4.3. Welfare States and the environment

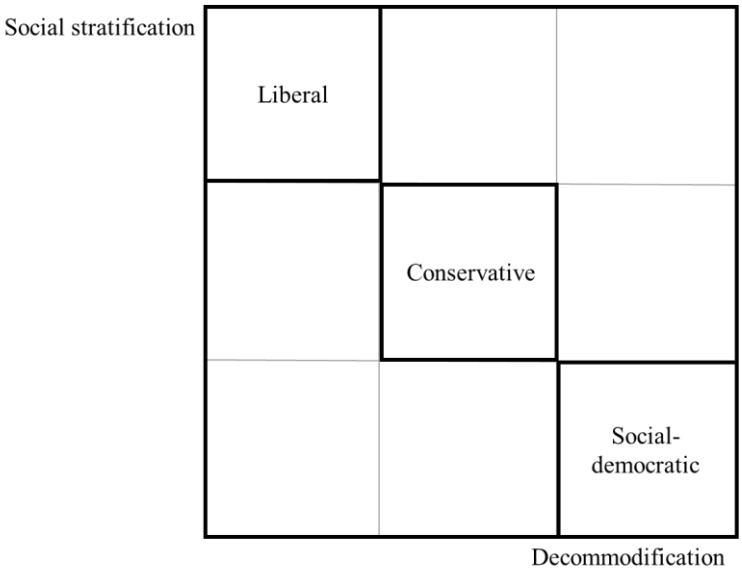
The reality of WS is complex and requires a definition and conception to enable subsequent analysis. In this thesis, we define WS as a series of institutions of a social, organisational and normative nature that assume the direct provision of social services, regulate private activities to shape the economy and provide cash benefits (Corlet Walker,

Druckman, & Jackson, 2021; Gough, 1979), to achieve economic security and reduce inequalities as social relations become increasingly commodified (Titmuss, 1968). Other features like public-sector entrepreneurship and innovation can also be attached to the WS in Western Continental Europe (Millward, 2011), but we do not consider them in our definition provided their contextual specificity.

The need to analyse WS amid this complexity enabled the possibility to focus on this aspect or the other of it, but given the broad literature related to the taxonomies of WS, and that they are a good synthesis of their potentialities in the provision of social protection, it makes sense to delve into the classification of regimes according to their differential traits. These traits are a reflection of the differential institutional configuration that supported the emergence of WS and can be seen as combinations of four main institutions that operate the provision of social protection and welfare: the family, the community, the state, and the market (Muñoz de Bustillo, 2019). To this extent, we start from the classification suggested by the seminal work of Gøsta Esping-Andersen (Esping-Andersen, 1990), as well as the later literature that drew from it (Arts & Gelissen, 2002; Ferrera, 1996; Koch & Fritz, 2014).

Esping-Andersen (1990) proposed a categorisation under two indicators: decommodification and social stratification. Decommodification is the strong likelihood of reaching a satisfactory standard of living and well-being independently of the level of market implication. Social stratification is the difference between individuals or groups of individuals based on characteristics that reflect their comparative living conditions, frequently income. Under this dimensionality, WS are classifiable into three groups: Social-democratic, Conservative and Liberal (Figure 1-8). Social-democratic regimes combine high decommodification and low social stratification. Conservative WS show a medium level of decommodification and stratification. Finally, Liberal typologies display low decommodification and high stratification.

Figure 1-8 Welfare regimes according to decommodification and social stratification



Source: Own elaboration.

Any taxonomy is useful to label realities for identification and analytical purposes. However, it is also limited given the complex nature of such realities. Coherently, to balance complexity and simplifications, scholars have also proposed some alternatives to Esping-Andersen's taxonomy (Arts & Gelissen, 2002; Ferrera, 1996). Ferrera (1996) focused on Europe, as we do in this thesis, with a higher contextual specificity than that pictured by Esping-Andersen, and distinguished between Anglo-Saxon, Bismarckian, Scandinavian, and Southern European regimes. In contrast, subsequent works that mixed the basis of Esping-Andersen and a near notion of the spirit behind Ferrera's proposal determined the existence of Social-democratic, Conservative, Liberal, Mediterranean, and Eastern regimes (Koch & Fritz, 2014). As the works of Koch and Fritz have inspired our empirical analysis, we suggest their categorisation for comparative purposes (Table 1-2).

Table 1-2 Preliminary classification of welfare regimes

Regime	Distinctive traits			Countries
	Decommodif.	Social strat.	Context	
Social-democratic	Similar: High	Similar: Low	Diverse	Austria, Belgium, Denmark, Iceland, the Netherlands,

				Norway and Sweden
Conservative	Similar: Medium	Similar: Medium	Diverse	Finland, France, Germany, Italy, Japan and Switzerland
Liberal	Similar: Low	Similar: High	Diverse	Australia, Canada, Ireland, New Zealand, United Kingdom, United States of America
Mediterranean	Diverse	Diverse	Similar: Area, History	Greece, Portugal, Spain and Turkey
Eastern	Diverse	Diverse	Similar: Area, History	Czech Republic, Estonia, Hungary, Poland, Slovakia and Slovenia

Source: Own elaboration based on Koch & Fritz (2014).

Notwithstanding, this classification should be observed with caution. Apart from the mentioned limitations of any taxonomy, as commented previously, we consider that some "labels" are subject to discussion. Particularly, there is a growing consensus on the Social-democratic nature of the Finnish welfare regime, as well as on the Mediterranean adequacy of the Italian case, despite some Conservative traits (del Pino Matute & Rubio Lara, 2013). In this respect, we reiterate that our adhesion to this classification is related to the need of ensuring comparability between works. As the work of Koch & Fritz (2014) is a relevant source of inspiration for this research, we consider their taxonomy to enable a comparison with our outcomes. However, as we indicate in our methodological framework in Section 1.5 and our procedures in Section 4.3, the underlying classification

of WS does not determine our results: the optimal typology of eco-social conjunctions to test synergy is strictly based on data.

The classifications based on Esping-Andersen's taxonomy have remained meaningful despite the events that occurred over the last decades in the socioeconomic dimension of WS and said limitations. These events consist of a transformation of Fordism motivated by successive crises, reconfigurations of economic thought and globalisation (Rueda, 2012), and can be summarised as follows (Gómez Serrano & Buendía, 2014):

- A more moderate economic growth, which has limited the capacity of WS to secure public revenues and subsequently, public expenditures, and is concomitant with an increasing fiscal fraud, financialisation, and, ultimately, globalisation. Globalisation is essential to understand the evolution, as this phenomenon is responsible for conditioning fiscal and labour rules, limiting the capacity to fund public policies through fiscal competence, and causing tensions in the demand for greater protection support (Muñoz de Bustillo, 2019).
- The momentum of liberal schools of thought and their followers in policy design potentiated privatisation and commodification (Korpi & Palme, 2003).
- The demographic transformation, in which concur ageing, a reduction of fertility, a considerable increase of life expectancy, the consequent increase of retired population, and a reduction of the relation between active and dependent population (Esping-Andersen, 2000).
- Finally, regarding the labour market, the proliferation of part-time and temporary jobs, unemployment in the young population, the scarce remuneration in low-skilled positions, the delay in the access to the first job connected with the demand for education and higher qualifications, the instability of family as a social institution, and the worsening of labour quality and social protection.

As Gómez Serrano & Buendía (2014) showed, these reconfigurations, although generalised, have generated specific impacts across typologies that have modified their initial scopes.

Conservative regimes have faced a more notable downgrading of the social pact, which materialised as legislative restrictions, reductions in key social spending like retirement, and erosion of universality.

Liberal regimes traditionally presented a low relevance of informal social institutions, a high contribution of the market in the provision of welfare services, elevated confidence in individuals to satisfy their needs, and a marginal universality of public welfare. They showed the most notable transformations in the past decades (Pierson, 1994) until the financial crisis of 2008, which in contrast did not alter the previous evolution. Said transformations reinforced the inherent traits of these regimes and consisted of downgrading the role of unions, cutting the generosity of retirement pensions, reducing the generosity and extension of unemployment benefits, and introducing further privatisations. Though, they simultaneously promoted a frontal boarding of poverty through complementary incomes and the emergence of public-private agreements to provide social services, with the only exception of health services, which remained largely universal (Gómez Serrano & Buendía, 2014).

Social-democratic regimes have persistently been considered the truest to their original principles, as they have not undergone sharp variations. On the contrary, they have built up over their primary results in the 1970s (Moreno, 2013; Rubio Lara, 2013; Rueda, 2012). On the one hand, a high-skilled labour supply, the personalisation of job search, and flexicurity enable full employment. On the other hand, low wage dispersion, high activity rates, work-life balance, high generosity, and universality of benefits are based on an equally elevated fiscal pressure, hence promoting low dependence on informal social institutions and between individuals. Even if Social-democratic WS seem to remain more attached to their core principles, we can observe a certain level of denaturalisation of some traits or retrenchment (Buendía, 2015; Buendia & Palazuelos, 2014). In the case of the Nordic countries, and particularly Sweden, this phenomenon is reflected in the promotion of public-private management of pensions, the introduction of actuarial techniques for the calculation of benefits (Belfrage & Ryner, 2009), the increasing participation of markets in the provision of social services (Buendía García, 2012) and a slight limitation of universality (Moreno, 2013).

Regarding Mediterranean regimes, the evolution of this derivation has been more ambiguous (Moreno & Mari-Klose, 2013): as WS were attempting to close the breaches of universality and generosity in comparison with more developed regimes, they were also facing some minimalist trends. Minimalism has been significantly associated with lower fiscal pressure, the prevailing traditional role of informal social institutions, notably family, in constant evolution during the last decades, globalisation, and the fiscal rules imposed to enter the Euro community (Navarro, 2000). The crisis in 2008 was a determinant factor for Mediterranean regimes, as they suffered its consequences more harshly, particularly increasing unemployment levels, decreasing the quality of jobs and the level of wages, reinforcing gender inequality and promoting part-time jobs (Rodríguez

Cabrero, 2011). When the pandemic started, in 2020, Mediterranean regimes were still recovering from the previous collapse.

Despite these nuances, we observe four trends in public welfare that have marked the two first decades of the 21st century (Gómez Serrano & Buendía, 2014):

- The individualisation of risks, contrary to the collectivisation of risks, which moved forward the foundational basis of WS.
- The emergence of new social agents to provide social protection, such as religious institutions and other non-governmental organisations, therefore representing a return to the social mechanisms of welfare before the establishment of WS. These institutions have a limited range of action in comparison with formal governmental agents and have restrictions regarding infrastructure, capacity, and resources.
- The increasingly relevant role of informal social institutions, notably family. In parallel with the emergence of new social agents, there is a re-emergence of traditional institutions of social support.
- The deterioration of fiscal basis, because of the mentioned dynamics on the side of the economy, in combination with a proliferation of indirect taxation on the side of the public sector. Hence, public revenues are increasingly attached to economic cycles and WS are more limited to acting in case of crises than in previous designs, in which direct taxation represented a higher fiscal basis.

In this evolutive context, whether denaturalisation or potentiation of the original features of welfare regimes, the current developments in the field of just energy transitions, and socio-ecological transitions to sustainability in general, are increasingly demanding WS interventions to ease the process. The role of WS in the transition is critical, as they could be facilitators in the process and recipients of the environmental impacts. As recipients, WS are subject to evolving technological, environmental, and demographic dynamics, but the environmental evolution would be the determinant factor to explain the future of welfare (Muñoz De Bustillo, 2020). As facilitators, although the environmental status is a global issue, the role of the contemporary state should not be overlooked (Bäckstrand & Kronsell, 2015; Duit, Feindt, & Meadowcroft, 2016). In the context of climate change, the states are demanded to finance adaptation and mitigation projects, face more notable and frequent natural disasters, and compensate for the fiscal regressivity of mitigation policies (Bailey, 2015; Johansson, Khan, & Hildingsson, 2016).

A central element of the relations between WS and the environment, and subsequently the process of energy transition, can be found in the Nordic models

(Westholm & Beland Lindahl, 2012). The energy transition of Sweden, particularly, could be a non-intentional side effect of the welfare regime and parallel model of competence that developed during the 1980s. The WS generated the requisites of a decentralised energy model by establishing a uniform, standardised, and powerful local administrative structure. Simultaneously, the echoes of the rising energy prices in the 1970s motivated the emergence of a model of competence in which the Swedish regions mobilised their local resources. The ultimate detonator was the downgrading of the interventionism of the central state, which became a supervisor of decentralised actions.

Nevertheless, the Swedish case is particular and the configuration of the WS is not an immediate guarantee of positive environmental performance. Even if environmental interventions flow through the structures of the welfare regimes, social and environmental goals and interventions can be conflicting (Dryzek, 2008; Koch & Fritz, 2014). As Dryzek (2008) emphasises, environmental policies can be seen as social policies with the sole exception of their scope. While social policies face individually unpredictable, but collectively predictable risks, environmental policies address collectively unpredictable risks.

Some of the cited works and related theories (Bäckstrand & Kronsell, 2015; Bomberg, 2015; Borgnäs, Eskelinen, Perkiö, & Warlenius, 2015; Dryzek, Downes, Hunhold, Schlosberg, & Hernes., 2003; Duit et al., 2016; Eklind Kloo, 2015; Jakobsson et al., 2018; Meadowcroft, 2008; Sommerer & Lim, 2016; Vilella-Vila, 2012) analyse the establishment of ES, beyond WS. ES aim at managing the environment and its social interactions through continuous political activity (Duit et al., 2016) to achieve a sustainable future domestically and globally (Bomberg, 2015). In the construction of the incipient ES, not only limited to Western countries (Sommerer & Lim, 2016), we can distinguish two phases (Meadowcroft, 2012). First, the establishment of central environmental agencies as an attempt to control pollution and elaborate environmental agendas. Second, the dilution of these attempts in a systemic and long-term ambition, in which environmental decision-making joins economic issues, through a diversity of political instruments and international cooperation. From a practical viewpoint, WS and ES are not significantly differing structures (Meadowcroft, 2008). Both are political responses to long-term social changes concerning industrialisation, urbanisation, and democratisation, which theoretically cannot be faced through markets and voluntary actions. Furthermore, both structures impact normal social interaction while facing significant limitations in the political and economic spheres.

In contrast to the well-established trajectory, theorisations, and empirical efforts around WS, much remains to be said concerning ES, as a relatively recent proposal that has not constituted a close reality yet. Consequently, by adhering to this theoretical framework of WS, we seek to contribute to further the idea of ES in Chapter 4, through

analysis and test of the hypothesis of synergy between WS and ES, i.e., between social and environmental dimensions.

Once this triple theoretical framework has been drawn, we determine the methodological framework of this research in the following Section.

1.5. Methodological framework

The methodological framework of this thesis is responsive to the theoretical framework that has been delimited and the goals of the research.

The methodology is triple, to address adequately the three secondary objectives in which our way to the main objective is divided. It consists of an unweighted systematic review of the literature, an exercise of simulation inspired by System Dynamics (SD) of the socioeconomic impacts of the transition to renewables in Leonese areas and the use of Ward's hierarchical clustering algorithms supported by Thorndike's optimality criterium to test the hypothesis of synergy.

I. Unweighted systematic review of the literature

The method used to elaborate the state-of-the-art consists of an unweighted systematic review (Sovacool, Axsen, & Sorrell, 2018). After a contextualisation based on reports and working papers, we have defined the search strings to retrieve the target papers from scientific databases. Subsequently, we have classified them and screened the results to focus on the most relevant documents. Afterwards, the number of references has been broadened by consulting the citations of the documents and screening them again. Finally, the information has been synthesised.

II. Dynamic simulation of local rural areas under data shortages inspired by SD

Most of the literature about local energy transitions has adopted qualitative approaches and that about modelling has repeatedly neglected local scales (Naumann & Rudolph, 2020; Turnheim et al., 2015). Modelling, and quantitative techniques in general, and local cases are not incompatible (Selvakkumaran & Ahlgren, 2018b). There is a single challenge to face: data shortages. In this vein, SD has been recently pointed out as a relevant tool to overcome the unavailability of data, given its suitability to incorporate data from varied sources, including first-hand information and insights from stakeholders on the ground (Selvakkumaran & Ahlgren, 2020). SD enables co-creation, so stakeholders can take the lead in the design of their modelling, hence capitalising on the procedural dimension of justice.

In current political plans, there is a lack of tools to provide quantitative certainty to the unfolding of the process. Modelling can be revealing if we can properly ease data scarcity. Notwithstanding, as far as modelling adopts complex approaches that result

unaffordable to the variety of stakeholders in these local rural areas with limited means, the conclusion risks being a worthless bit of paper. Accessibility is mandatory and specially considered in our approach.

After revising the current political plans for León, we determine the main socioeconomic dynamics, which are subsequently translated into an intuitive stock-flow rationale based on SD. To feed the model, we extract energy, human, and environmental data from the most recent reports of stakeholders on the ground and public registries. The simulation is carried out by introducing incremental parameters regarding the tenders of solar, wind, and biomass power ceteris paribus, to test their effects on the horizon 2030.

III. Ward's hierarchical clustering algorithms and Thorndike's optimality

Clustering is a well-known technique in multiple fields. Clustering algorithms are mathematical tools that aim at determining the most internally homogeneous groups in a sample of diverse individual observations. Their main goal is to provide coherent and robust classifications based on direct evidence.

Based on the state-of-the-art, we apply a hierarchical algorithm. This type of clustering technique aims at calculating a taxonomy of observations at different distances between the observed individuals, strictly based on data and without introducing the assumptions of other types of algorithms. Ward's method is the most common and accepted manifestation of this tool.

To maintain the objectivity of the method, we employ Thorndike's criterium of optimality to determine the optimal combination of groups in our sample considering the vast taxonomies that the hierarchical algorithm offer (Thorndike, 1953).

This method allows the analysis of cross-section data. Nonetheless, the data that we use to test synergy adopts the form of a panel, given the country and time dimension. To carry out a time-conscious analysis, we have additionally created a methodological artifice that gathers the required information to extract coherent conclusions through the gathering of cross-section results over time: the concurrence matrix. This auxiliary matrix presents the probability of finding that countries, two by two, belong to the same cluster in the sample.

1.6. Structure of this thesis

This thesis is formally organised into five Chapters. After this initial Chapter that discloses the motivation behind it, the goals and hypotheses, and the theoretical and methodological background of the research work, three core Chapters follow. These three Chapters are dependent in sequence, as a previous Chapter lays the ground for the next one, in the same order in which we have implemented the research procedures. Finally, a

Chapter of conclusions closes this exposition, and a list of the bibliographic references completes the document (Figure 1-9).

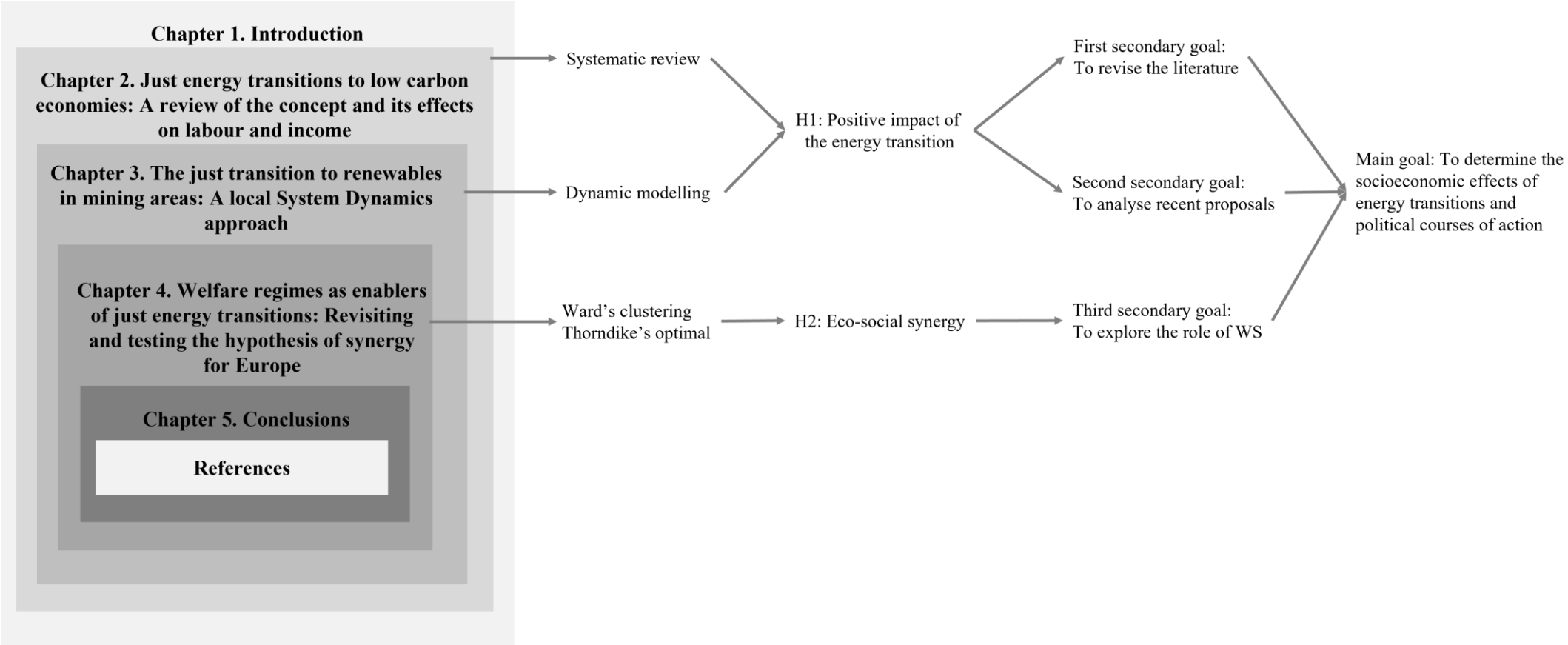
Each one of the three core Chapters responds to a secondary goal, hence, in conjunction, they aim at fulfilling the main goal of the research. Parallelly, they align with each of the three methodologies that have been applied to test the hypotheses under our theoretical framework.

Chapter 2, entitled "Just energy transitions to low carbon economies: A review of the concept and its effects on labour and income" presents the results of the literature review that was carried out at the beginning of this thesis. It delimits the topic under study, contributes to its theoretical demarcation, detects the key issues, as well as the less studied ones, finds research gaps and weaknesses, and finally, proposes a research agenda. This Chapter fulfils the first secondary goal: "to revise the literature about the socioeconomic effects of the transitions to sustainable energy models and the framework of just transitions". The first methodology, an unweighted systematic review, addresses the first hypothesis: the sign and nature of the effects of the energy transition on employment and income. This review, jointly with the corresponding Section of the theoretical framework, is published as a review article: García-García, P., Carpintero, Ó., & Buendía, L. (2020). Just energy transitions to low carbon economies: A review of the concept and its effects on labour and income. *Energy Research & Social Science*, 70, 101664. https://doi.org/10.1016/j.erss.2020.101664.

Chapter 3, under the title "The just transition to renewables in mining areas: A local System Dynamics approach", provides our estimation of impacts on a challenging and neglected scale, the local rural level, through the close case of León. It is based on a political, normative, and socioeconomic context, and a posterior determination of strategical advantages. Subsequently, based on the context and advantages, it introduces and estimates an intuitive and scalable model inspired by SD to derive the results of a transition towards RES in two areas under restructuring regarding the two main hotspots of the Leonese case: employment and land requirements. This research work is closely linked with the proposals of just restructuring launched by the Spanish MITECO in the last years and is nurtured by the information of the main instrument of public intervention, the CTJ. As an additional result of the process of revision of the current political plans, it discloses the limitations and margin of orientation by following the theoretical framework and the insights of the review. It aims at fulfilling the second secondary goal: "to analyse the most recent proposals for a just transition of the areas under study and determine the strengths and weaknesses of public plans, as well as to offer quantitative insights into the development of the restructuring to find the priorities of future political agendas and stakeholders' action". It applies the second methodology, the dynamic simulation inspired by SD, to complete the study of the first hypothesis, this time from a local perspective.

Chapter 4, “Welfare regimes as enablers of just energy transitions: Revisiting and testing the hypothesis of synergy for Europe”, addresses the potential of current WS to enable a transition to ES, thus providing justice in the process of restructuring. It capitalises on the theoretical formulations that can be found in the associated literature on eco-social synergy and proposes rearrangements to improve the alignment of theoretical-empirical efforts as well as the coherence and consistency of the results. Notwithstanding, all procedures preserve a linking wire with previous research to ensure comparability. It applies the third of our methodologies, Ward’s hierarchical clustering algorithms and Thorndike’s optimality, to test the second hypothesis, i.e., the hypothesis of eco-social synergy. Based on the results of the test, it proposes a reflection on the capability of SW to enable a just transition and performs a downscaling of SW tools from the global or national scale, in which they are originally pictured, towards the local scale, with a focus on the facilitating institutions of the Leonese case. This Chapter, except for the local derivation, is published as a research article: García-García, P., Buendía, L., & Carpintero, Ó. (2022). Welfare regimes as enablers of just energy transitions: Revisiting and testing the hypothesis of synergy for Europe. *Ecological Economics*, 197(July), 107434. https://doi.org/10.1016/j.ecolecon.2022.107434.

Figure 1-9 Structure of the thesis



Source: Own elaboration.

Chapter 2

JUST ENERGY TRANSITIONS TO LOW CARBON ECONOMIES: A REVIEW OF THE CONCEPT AND ITS EFFECTS ON LABOUR AND INCOME

The current twofold crisis, environmental on the side of resources and residues and social, is the motivation of this research work. To face this situation, which has been determined as the greatest challenge of the century, the notion of just energy transitions has (re)emerged from its unionist roots to cope with increasing attention worldwide in the range of energy transitions, and broadly in the domain of socio-ecological transitions to sustainability.

Introducing the adjective "just" in the denomination of the process is not a mere addition. It involves recognition. We have learned from history that energy transitions imply an intricate shift in energy generation, distribution, storage, and usage. The differential element regarding this renewed conception is the acknowledgement of interconnected socioeconomic and political rearrangements and the subsequent consideration of these rearrangements as unequally distributed in a society that has already suffered notable deterioration after two deep crises in the 21st century.

As references to the concept multiply, there is a need to determine what it is, what we know about the process and scope of justice in energy transitions, what we do not know, and what we should do to accomplish it, with a political and scholarly focus.

This second Chapter systematises the findings of the literature review that lays the ground for this work and analyses the results conditioned to their methodological framing. Thus, this Chapter aligns with our first secondary goal, "to revise the literature about the socioeconomic effects of the transitions to sustainable energy models and the framework of just transitions", and is devoted to partly addressing the first research hypothesis, i.e., to determine the sign of the impacts of the energy transition on labour and income.

Section 2.1 presents a preliminary approach to the topic through bibliometrics. Section 2.2 introduces in greater detail the methodology to perform the review. Sections 2.3 and 2.4 disclose the methodological state-of-the-art and the survey of empirical effects on labour and income with a focus on institutional and financial barriers, respectively. Section 2.5 suggests a direction for future research efforts by detecting the main niches

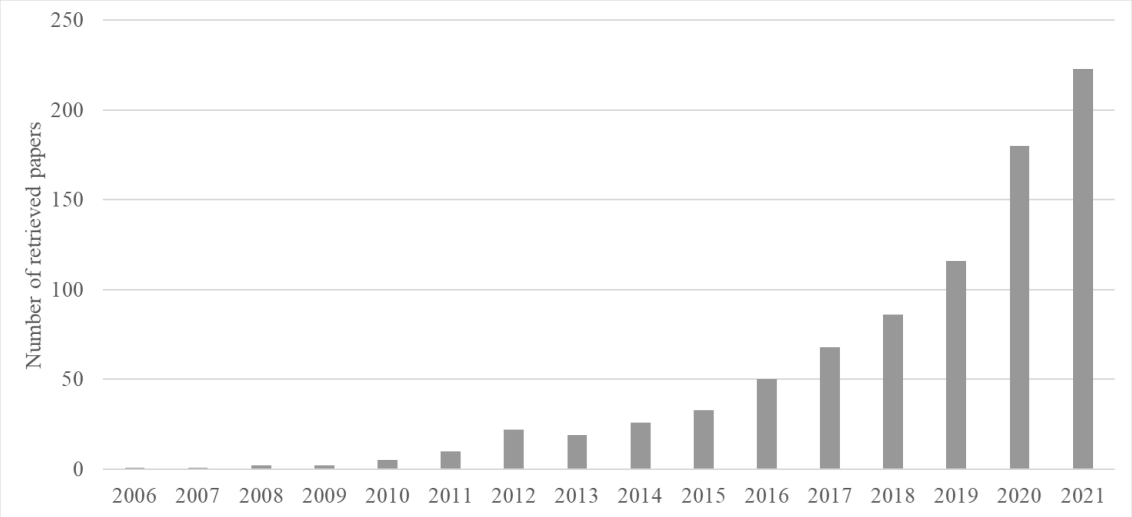
in the topic and elaborating a research agenda accordingly. Finally, Section 2.6 gathers the main conclusions.

2.1. Preliminary bibliometrics

A preliminary search for the concept of just energy transition applied to low carbon economies in bibliographic databases such as ScienceDirect and Web of Science reveals significant traits of the topic that motivates this research.

The first papers that study explicitly this issue can be found as soon as 2006. Greater interest, yet relatively modest, can be progressively detected since 2010. This appeal adopts the form of an exponential evolution from 2015 to the present moment, probably fuelled by the UN's SDGs (Figure 2-1).

Figure 2-1 Number of retrieved papers about just energy transitions to low carbon economies per year, 2006-2021



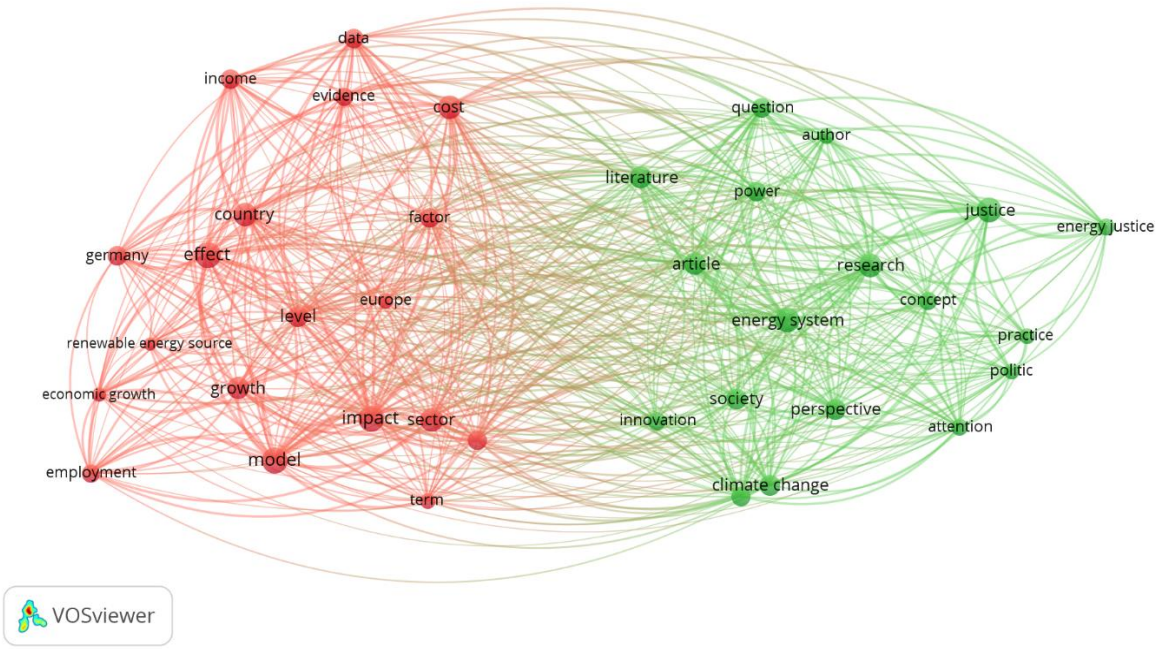
Source: Own elaboration.

The processing of these papers through text mining techniques and linguistic algorithms (Figures 2-2 and 2-3) (van Eck & Waltman, 2018) reveals relevant bibliometric insights that match with the results of the literature review, as presented in the following Sections:

First, the predominance of sectorial studies of impacts at a country level, mostly in Europe and particularly in Germany, through models of economic growth, with a focus on employment and income (Figure 2-2).

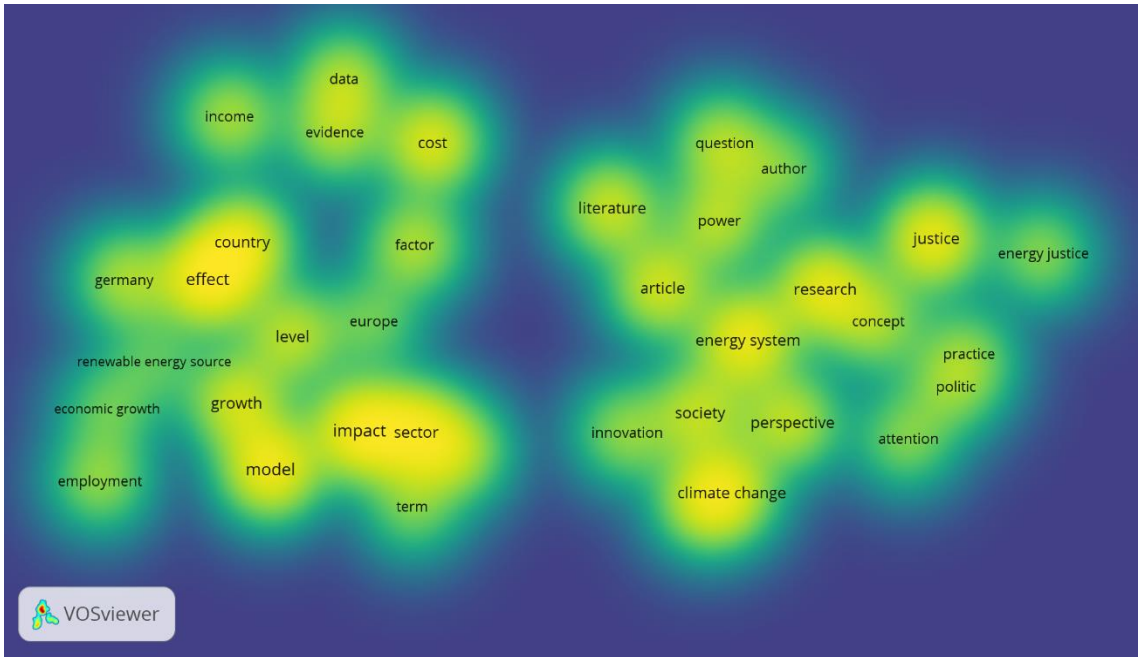
Second, the analysis of energy systems and climate change has congregated greater attention than energy justice, agents' practices, and policies (Figure 2-3).

Figure 2-2 Bibliometric network and clusters of just energy transitions



Source: Own elaboration through VOSviewer.

Figure 2-3 Conceptual density heatmap of the bibliographic network of just energy transitions



Source: Own elaboration through VOSviewer.

These preliminary insights provide an initial context for the review. Yet, a proper systematic review in the terms described in the methodology is required to obtain a detailed state-of-the-art.

2.2. Methodology

The method used to elaborate the state-of-the-art consists of an unweighted systematic review (Sovacool et al., 2018) structured in the following phases (Figure 2-4):

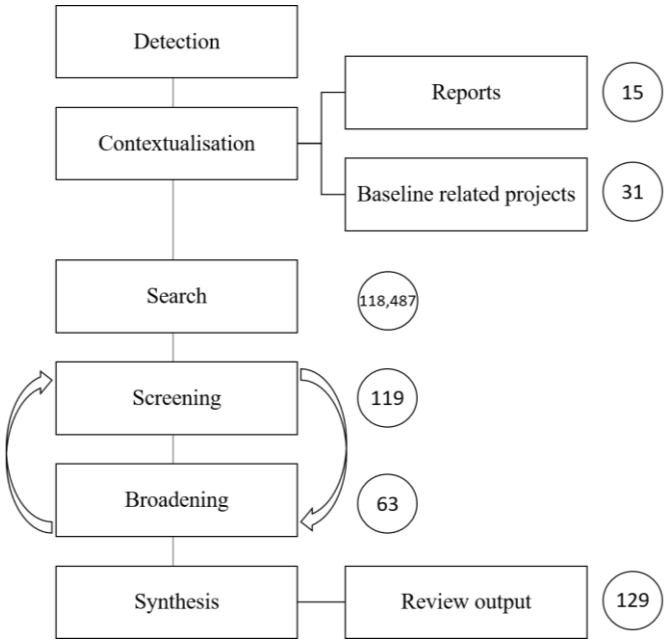
Phase 1. Contextualisation. A revision of reports and working papers from international organisations is done, as well as a review of the most commonly referenced articles in related academic projects. This leads us to conclude that a review on just energy transitions must focus on labour and income.

Phase 2. Searching in scientific databases and screening the results. Diverse search strategies are launched to retrieve papers containing the different conceptual combinations detected in the previous phase, e.g., "just energy transition", intitle: "energy transition" AND employment OR jobs OR income. Once the total number of articles found in such databases has been gathered, they are classified to determine their interest in this research by relying on topicality and conciseness. The effects on labour and income especially cover the case of developed countries, due to the relative scarcity of studies based on data from less developed areas.

Phase 3. Broadening references. From the total number of selected papers, a search for more references is done by checking the bibliography their authors used. The recovered references are processed as done in the previous phases.

Phase 4. Synthesis. In the final phase, we extract the meaningful information from the review in a summarised format.

Figure 2-4 Review process and reduction of references (number of retrieved papers in circles)



Source: Own elaboration.

This methodology shares the same limitations as other systematic reviews in the field of energy research (Sovacool et al., 2018), i.e., it is a research strategy intensive in resources, narrowly focused on restrictive questions, with an implicit preference for quantitative research and led by an additive approach. To avoid these inherent limitations, we have taken the precaution of including the conceptual and institutional overview of a qualitative nature presented in the form of a theoretical framework (Section 1.4.2) and a Section of barriers (Section 2.4.3) to compensate for the possible quantitative bias and the merely additive narratives derived from the review of methodologies.

The results of the application of this method are presented in the following Sections.

2.3. Methodological state-of-the-art

The predominant method to analyse the topic under study is the elaboration and application of models. The modelling of just energy transitions emerged from the attempt to integrate a growing environmental awareness with the Keynesian and Post-Keynesian approaches. This branch has started to develop models to assess economic inequality and job markets in connection with environmental limitations and alternative economic paradigms (Hardt & O'Neill, 2017), contributing to filling a gap in the research into transitions (Köhler et al., 2019).

As the models are diverse, they are classified into groups and subgroups (Hardt & O'Neill, 2017; Rosebud Lambert & Pereira Silva, 2012). The most widespread classification is also the most categorical. It considers the existence of numerical and analytical models according to their base; while earth system models, Integrated Assessment Models (IAMs), and Computable General Equilibrium models (CGE) are considered according to their level of detail (Stehfest, van Vuuren, Bouwman, & Kram, 2014).

Numerical models usually apply IOA (Input-Output Analysis), which is recurring in the literature (Lehr, Lutz, & Edler, 2012) and consists of a set of tables that show the flows of goods and services between intermediate units and final units (Markandya et al., 2016). They are useful as transformations propagated through supply chains, but they also present methodological limitations (Fragkos & Paroussos, 2018; Markandya et al., 2016): the difficulty of considering time lags, measuring feedbacks between prices and quantities, the linearity and invariance of the coefficients, the generalisations of sectors, the homogeneity of outputs, and the lack of economies of scale. What is more, their reliability is inherited from primary data sources and they tend to overestimate job creation. Input-Output Tables (IOTs) are also scaled on a national level, so it is difficult to use them in a regional or local perspective (Rosebud Lambert & Pereira Silva, 2012).

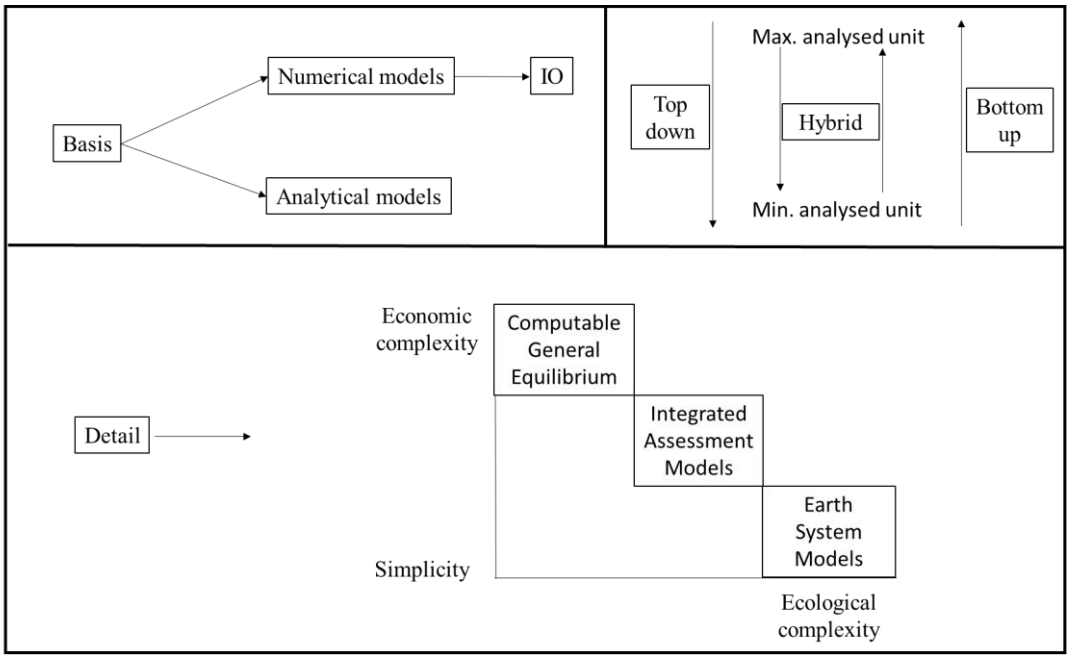
Analytical methods are commonly used for regional or local studies instead. They are more transparent, but cannot predict indirect or induced jobs.

Regarding the perspective of modelling, there are two main, widely used approaches: the top-down approach and the bottom-up approach. When applied separately, these approaches have significantly demonstrated weaknesses (Bacon & Kojima, 2011; Kammen, Kapadia, & Fripp, 2006). The top-down approach relies on a static Input-Output (IO) methodology that cannot offer an accurate level of detail in sectorial estimates. Moreover, it is not appropriate to capture the shifts caused by investment variables and offers other inconveniences attached to the timing of the model. The bottom-up approach configures limited analytical models dependent on accounting techniques that do not provide the big picture. It would therefore be useful to combine both approaches; benefitting from their strengths and avoiding their weaknesses. This combined approach is called "hybrid" and has been increasingly applied in recent research (Crespo del Granado, van Nieuwkoop, Kardakos, & Schaffner, 2018).

Apart from this classification, and according to the level of detail (Stehfest et al., 2014), earth system models contemplate a simple economic framework and a complex environmental background; while CGE rely on a complex economic frame despite a simpler environmental background. IAMs balance the complexity of environmental and economic systems. In methodological terms, increasing attention has been paid to the use of IAMs, such as IMAGE (Stehfest et al., 2014), ReMIND-R (Luderer, Leimbach, Bauer, & Kriegler, 2011) and EPPA (Wilkerson, Leibowicz, Turner, & Weyant, 2015), to the point of becoming the primary method for studying the transition.

While this classification gathers the most common terminology (Figure 2-5), it should be used with caution and an open perspective, since the empirical state-of-the-art is surpassing such restrictive classifications, as the existence of methodological intersections and hybrid approaches proves.

Figure 2-5 Categorical classification of models

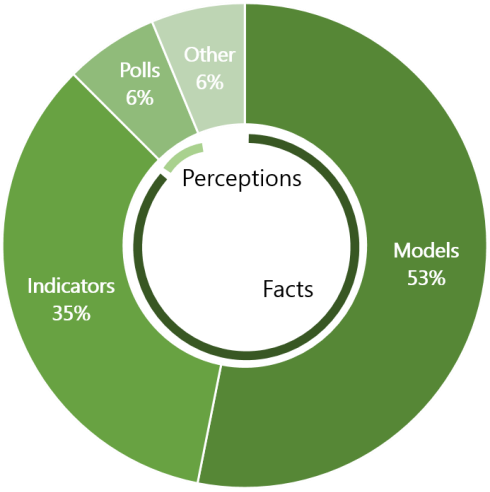


Source: Own elaboration.

Apart from this caution, we have found three increasingly generalised claims to remark. First, the growing call to allow Social Sciences to enrich this discussion (Sonetti, Arrobbio, Lombardi, Lami, & Monaci, 2020; Sovacool, 2014), besides the encouragement of the use of case studies (Ge & Zhi, 2016; Sovacool, 2014), the application of systemic thinking (Finley-Brook & Holloman, 2016) and the cooperation between fields (Jenkins et al., 2016) through transdisciplinary analysis (Heffron & McCauley, 2017). Second, the increasing interest in socio-metabolic approaches (Behrens et al., 2014; Fischer-Kowalski et al., 2012; Rodríguez-Huerta, Rosas-Casals, & Sorman, 2017) to understand the paths of societies and provide thorough comparisons, reinforcing the use of case studies (Ramos-Martin & Canellas-i-Boltà, 2008). Third, the explicit argumentations in favour of demand approaches, based on the risk of limiting the capacity of the models when it comes to the caption of social problems and impacts on welfare with full employment assumptions (Taylor, Rezai, & Foley, 2016). Concurrently, most of the published works are still based on growth paradigms. A lack of studies focusing on structural and transformative approaches had already been noticed long ago (Haxeltine et al., 2008), even though it is a recurring alternative found in theoretical studies, as stated in the theoretical framework.

In summary, the methodological composition of the state-of-the-art is presented in Figure 2-6:

Figure 2-6 Methodological composition of studies about the impacts of the energy transition on employment and income distribution



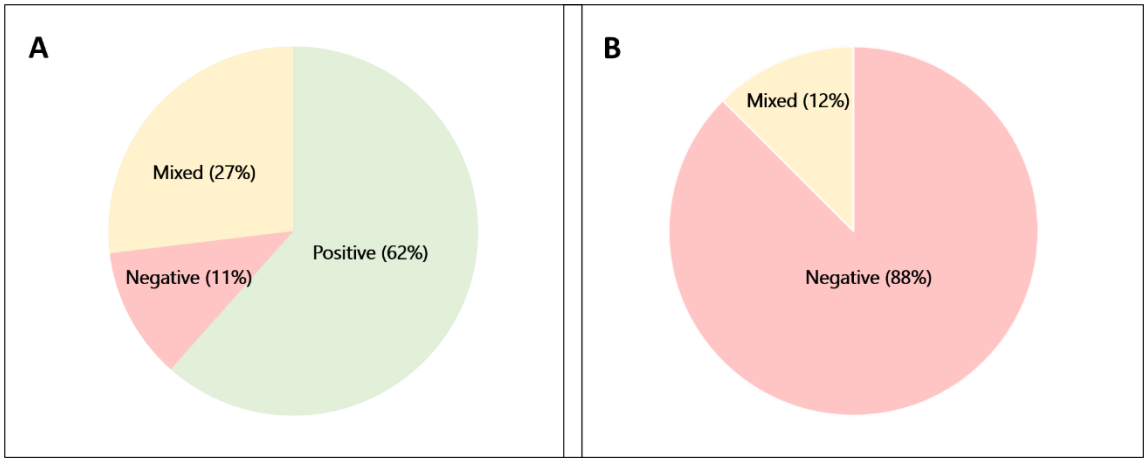
Source: Own elaboration.

Once this methodological framework has been set up, we are in a position to delve into the empirical effects set out by works in the field, as described in the following Section.

2.4. Survey of the empirical effects

By classifying studies in terms of the sign of the impact, we observe that most of them point to positive, yet small, effects on employment and notable negative effects on income distribution (Figure 2-7).

Figure 2-7 Sign of the effects concluded by studies about employment (Panel A) and income distribution (Panel B)



Source: Own elaboration.

This overview is developed in detail in the next Sections. The effects here summarised and gathered below come from studies before the SARS-CoV-2 pandemic causing COVID. Therefore, they do not contemplate its energy and socioeconomic impacts. Nonetheless, despite uncertainty, there are pieces of evidence that suggest that, even if the pandemic has deeply affected economic, social, energy and environmental dimensions, the effects of the transition do not differ significantly from those described in the absence of such perturbation (Guidehouse & Cambridge Econometrics, 2020).

2.4.1. Effects on employment

Most studies estimate the effects of the energy transition by calculating the variation in the number of direct, indirect, and/or induced jobs (Cambridge Econometrics, 2013). According to their geographical context, we have gathered them into three groups: supranational, national, and regional studies. Regarding studies at the European supranational level, the following can be highlighted:

Cambridge Econometrics (2013) used the model E3ME, considering the EU 2020 objectives, and found that this strategy would lead to a small creation of jobs via an increase in the investment variable. However, it was unable to offer a detailed disaggregation of job flows between sectors.

The Green Jobs study by Cambridge Econometrics also focused on the 2020 horizon, but data were taken at a moment of economic recession and did not consider major changes in the labour market or technologies. The study concluded that the variation in the number of jobs in Europe would be small and the most significant problems would be the consequences of a negative impact of labour mobility on aged workers and skill shortages in certain sectors. The role of labour mobility is a key to determining whether the effects are positive or negative.

Focusing on the 2030 horizon, both for the EU and other areas, E3ME has been updated and linked with the Warwick Labour Market Extension model (Lewney, Alexandri, Storrie, & Antón Pérez, 2019). The results reinforce those obtained in the previous application of E3ME (Cambridge Econometrics, 2013): again a positive outcome is found in employment due to investment, especially in energy, construction and related materials sectors. Cambridge Econometrics (Cambridge Econometrics, 2018) additionally provides the impacts of a shift to low-carbon transport following the energy transition through FEF (E3ME model) and ELAB: they concluded that a potentiation of hybrid vehicles would have beneficial results, while a proliferation of battery electric vehicles would destroy jobs.

NEMESIS and ASTRA models have also been applied to the 2030 horizon (Ragwitz et al., 2009). NEMESIS projected more optimistic conclusions, highlighting the

benefits of an accelerated deployment scenario. ASTRA was more pessimistic due to the differences attached to the investment variable.

At this moment, the focus is on 2030, but especially on 2050, according to action plans (European Commission, 2019; IRENA, 2018), or even on 2100, to deepen the research ambition (Petit, 2017). Nevertheless, the methodological approaches and the results of the cited studies are revealing and must be considered.

Towards the 2050 horizon, the E3ME and GEM-E3 models have been used (Cambridge Econometrics, 2013), as well as the LUT model (Ram, Aghahosseini, & Breyer, 2019). The E3ME estimates a net increase in employment equal to 1.2%, due to the fall in oil prices caused by the decrease in fossil fuel supplies, the increase in investments, the use of public revenues, the loss of jobs in polluting and intensive energy sectors, and the rise in electricity prices. The GEM-E3 also concludes that a net positive, yet small, impact is likely to be expected, despite the scenario. Notwithstanding, skill shortages push wages up and negatively affect the level of employment. In contrast, LUT predicts a high positive result, since renewables would contribute to 80% of employment by 2050 and the transition would potentiate economic growth, productivity, and efficiency.

Concerning the GEM-E3 model, Fragkos & Paroussos follow a hybrid approach, relying on a more remarkable Neoclassical background, thus prioritising supply rather than demand (Fragkos & Paroussos, 2018). As a result, they estimate creation and reallocation of jobs of around 1% of the European labour force. Again, a positive yet insignificant outcome is found. Skill shortages are not so important in this update, probably because of the methodological background.

Additional studies in the EU conclude that the transition has an especially positive effect on the energy sector. However, the measures implemented cause a rise in prices that negatively impact production and employment in the rest of the sectors. According to their authors, the negative effects can be partially tackled through market integrations (Creutzig et al., 2014).

In contrast with the ex-ante nature of these works, studies that look at the past through counterfactual methods can also be found (Markandya et al., 2016). Markandya et al. (2016) use the IO method applied to past data on electricity and gas from a multiregional perspective to find spill-over effects caused by changes in the energy system. Its conclusion is coherent with the preceding ex-ante studies: an increase in employment can be detected after the implementation of sustainable energy measures.

Besides the European supranational level, there are also abundant studies applied to national and regional contexts that most often emphasise the uneven distribution of impacts across them (Gambhir et al., 2018). Among these studies, certain cases are

presented as paradigmatic: Germany is the most analysed and cited case (Pegels & Lütkenhorst, 2014) under a diverse set of methods referenced below; the Netherlands, using the CGEM ThreeME model (Bulavskaya & Reynès, 2018); Italy, with a Lotka-Volterra growth model (Bernardo & D'Alessandro, 2016); France, using directly the IO methodology (Perrier & Quirion, 2017) and the EUROGREEN model (D'Alessandro, Cieplinski, Distefano, & Dittmer, 2020); and Catalonia, using the MuSIASEM model (Rodríguez-Huerta et al., 2017).

Germany has generated more literature than any other country, in most cases to point out the negative effects of the German energy strategy (*Energiewende*), especially on employment and equity (Fischer, Hake, Kuckshinrichs, Schröder, & Venghaus, 2016). However, these studies are frequently conceived from an exclusive point of view and do not aspire to observing the big picture, since they only focus on electricity (mainly as a reflection of the national strategy, which is entirely focused on electricity) (Unnerstall, 2017).

Notwithstanding, the German case has served to clarify some transcendent conclusions. Fischer et al. (Fischer et al., 2016) offer two important facts. First, the key to analysing the job variations caused by the transition is not gross employment, but net employment: gross employment shows a positive trend as long as renewables create new job positions; however, net employment measures whether the destruction of jobs on older, conventional sources are replaced or not by the creation of jobs in renewables. Second, the macroeconomic effects of the transition are deeply determined by the speed of its implementation. The speed is a political variable that can be used to influence the outcome, determining the level of macroeconomic and environmental costs assumed by society. Many studies support a fast transition based on Research and Development (R&D), the backing of social agents, and the development of cost-competitive renewable technologies (Bromley, 2016), apart from the context of globalisation (Kern & Rogge, 2016). In contrast, other authors are sceptical in regard to speeding up the process (Smil, 2010b), or they are even sceptical about the full concept (UNU-WIDER, 2017). Apart from the speed, the outcome depends on the situation of the economy regarding the production possibilities frontier, the prices of primary factors, the conditions of flexibility in the job market and the labour intensity (Fragkos & Paroussos, 2018).

Focusing on solar and wind energy, the two strategic sources for the transition; while most employment is created by investment in installations, a growing number of jobs are generated in maintenance and operation services. Although the importance of investment is clear, export markets are also a key variable, in line with other studies that complain about recurrently omitting it (Markandya et al., 2016). Markandya et al. (2016) find, through their counterfactual method, that employment creation follows geographic patterns and is more dispersed than expected. In this vein, and looking to future

estimations (Sievers et al., 2019), studies conclude an overall positive impact on growth and employment, but worrying nuances are also found in the geographical distribution of impacts across Germany. The construction sector is again the winner in terms of employment along with the energy sector, while the rest of the economy suffers the negative impact of the rise in energy prices.

Likewise, we can find a positive net effect on economic growth, boosted by investment and dependent on market flexibility (Blazejczak, Braun, Edler, & Schill, 2014). Effects on employment are small and positive if the labour market is rigid, and the results tend to improve as it gains flexibility. The energy shift generates a restructuring process that requires an improvement in skills.

The PANTA RHEI model, applied to Germany, concluded that the deployment of renewable energies would increase net employment, especially from 2020 onwards (Lehr et al., 2012), pointing out the relevance of international trade flows in determining the result and concluding that the future effect on gross employment would not be as fast as it was in the past.

Apart from Germany, other recurring national cases in the literature are the Netherlands, Italy and France.

In the Dutch case (Bulavskaya & Reynès, 2018), the model reflects the possibility of creating 50,000 full-time jobs by 2030, linked to a 0.85% increase in the GDP. The effects are derived from the analysis of electricity generation and prove the potential of wind and solar sources, with a higher labour and capital intensity. The capital intensity is the factor that, once again, serves to accentuate the importance of the investment variables. The authors conclude that renewable energy systems are more beneficial for the Dutch economy than conventional ones.

In the Italian case (Bernardo & D'Alessandro, 2016), a Lotka-Volterra growth model underlines the link between employment and income distribution. The introduction of SD provides flexibility and allows the feedbacks occurring among the modules of the model to be visualised. A certain degree of dynamisation is also looked for through simulation and prediction scenarios. The conclusion on jobs is consistent with the previous studies: the model predicts a 1.2 million increase in the number of jobs, showing again the relevance of the investment variable. However, this increase adds pressure on wages and the GDP falls slightly via investment and capital accumulation. The final situation is strongly determined by wage elasticity in the energy sector, on which the analysis focuses.

In the French case (Perrier & Quirion, 2017), as the data is not updated, the study does not consider the new political commitments. Besides, the energy transition is understood as an evolution towards a lesser usage of fossil fuels, focusing on the taxation

of CO_2 emissions. The study estimates the jobs in each economy branch and compares these to the national average by using five variables: final import rate, intermediate import rate, tax and subsidies, the portion of jobs in added value and wage level. The different results between branches are caused mainly by wage level and added value, although there are branches of the economy where the method is inapplicable. The results are coherent with those estimated at a European level.

To update this case, the EUROGREEN model has been revised (D'Alessandro et al., 2020). EUROGREEN, built on SD, analyses in a novel way the reaction of the French economy to the application of measures compatible with green growth, social equity, and degrowth scenarios. It concludes that green growth serves to reduce GHG emissions to the detriment of employment; social equity policies coordinate the same environmental performance as green growth with better social outcomes at the expense of a higher budget deficit; and finally, degrowth reaches the best environmental and social results, but also the highest deficit shares even if wealth taxes are inputted.

Continuing with the national level, but far from the European cases, we have found a work devoted to the Global South that analyses just energy transitions in a sample of less developed countries (Hirsch, Matthess, & Fünfgelt, 2017). It observes the profile of these countries through indicators and their degree of current and potential compliance with the SDGs. Additionally, it gathers statistics and short-term estimations from national authorities and international organisations regarding the impacts on employment levels. Under these indicators, South Africa, India, rural Vietnam, Philippines, Morocco, and Jamaica have experienced, and will experience, the positive impacts on employment of renewable and decentralised means of energy production. This report on the Global South has palliated the absence of cases and reliable data from less developed countries that we have found.

Finally, beyond national studies, there are pieces of evidence that seriously recommend taking the regional contexts into account (Gölz & Wedderhoff, 2018). It is necessary to highlight the MuSIASEM model that has been applied to Catalonia (Rodríguez-Huerta et al., 2017). MuSIASEM divides economic activities into general groups and considers just two scenarios. It coherently predicts an increase in jobs in the absence of skill shortages.

After this revision on the side of labour, the following points summarise the main findings:

- Analyses have to observe the effects by countries and regions, as they would be unevenly distributed within them (Gambhir et al., 2018).
- Studies have shifted from analysing the consequences of taxes on employment (Perrier & Quirion, 2017), to progressively widening their

scope. This is a strongly recommendable practice since the effects of taxes are only one of the diverse policies that determine the transition.

- Studies are progressively focusing on net employment, which is a strongly recommendable practice, but are only interested in volumes, which is not recommendable. Other important factors, such as the quality of jobs or the number of working hours, are constantly omitted, as noticed long ago (Schor & White, 2010), even if they are statistically significant variables (Zwickl, Disslbacher, & Stagl, 2016). Therefore, the creation of poor-quality jobs would be considered a positive outcome of the transition in these studies; while it should be considered a negative outcome, since poor-quality jobs damage the environment and do not improve the social situation (ILO, 2018). Papers also tend to use and reuse employment factors, even when they apply a wide range of methodologies (Cameron & Van Der Zwaan, 2015). The reuse of factors is not a recommendable practice, as it leads to inaccuracies. Likewise, research tends to focus exclusively on the energy sector and obviates the rest (Creutzig et al., 2014; Fischer et al., 2016), or estimates the diffusion from the said sector to other branches. Studies observing the big picture are few. This evidence again supports the necessity of applying systemic thinking.
- In the sectorial analysis, the most positive employment impact is recurrently found in the construction and green energy sectors. Overall, a positive, yet small, impact is found on the economy. These results are less favourable than expected, as renewable energies are thought to show a higher labour intensity than traditional sources (Bulavskaya & Reynès, 2018).
- The empirically significant variables to explain the results of the transition are: speed of implementation (Fischer et al., 2016), investment (Hall, Roelich, Davis, & Holstenkamp, 2018), imports, exports (Markandya et al., 2016), prices of primary factors, labour flexibility, labour intensity (Fragkos & Paroussos, 2018), and wage level and elasticity (Bernardo & D'Alessandro, 2016).
- While the ILO (2018) states that gender is an important variable for just energy transition analysis, as it could widen inequalities, gender worries are hardly present in the research.

2.4.2. Effects on income distribution

The criticism of the *Energiewende* is also found in the case of its distributional effects. The main claim is that the financing of the transition and the resulting higher

energy prices are regressive, so that the transition and the rise of energy poverty could be linked (Fischer et al., 2016). This conclusion is, notwithstanding, minimised by other studies (Unnerstall, 2017).

Generally, most of the studies about Germany are launched from an exclusive point of view (Unnerstall, 2017), so some authors end up proposing an increasing trust in market mechanisms (Frondel, Ritter, Schmidt, & Vance, 2010) as a reaction to the failures in the design of Germany's public policies instead of redesigning them to correct the errors, as in any other political process.

As far as the distributional matter is concerned, perceived burdens are of key importance (Groh & Ziegler, 2018), along with the objective effects. The high cost of the transition is detected as a problem by one-fourth of German citizens (BDEW, 2016) and many criticise that their distribution is unfair (Heindl, Schüßler, & Löschel, 2014). The preferences of individuals to assume the costs of the transition are correlated with demographic variables. Groh & Ziegler (2018) also conclude that the burdens are not as high as perceived and that the criticism could have been spread by lobbies from the most affected sectors (which do not have to match the most vulnerable sectors). Therefore, this criticism would lack any real basis and, instead, would have been promoted by the elites that risk the most in terms of losses caused by the transition.

Usually, the distributional analysis of the German case only focuses on electricity (Frondel, Sommer, & Vance, 2015; Gawel, Korte, & Tews, 2015; Schlesewsky & Winter, 2018). Unnerstall's discussion (Unnerstall, 2017) considers that this fixation is linked to the fact that the *Energiewende* is almost exclusively devoted to it. However, electricity is also the protagonist in other contexts (Crespo del Granado et al., 2018; Smil, 2016). This is partly because, in a transition, a major need is the development of electric grids in extension and capacity and the cost of development is imposed on customers. Consequently, areas where further improvements are needed must face a higher burden, for instance, in rural areas, where a lower income level is also found. This burden, interlinked with income dynamics, generates greater inequality. Focused metrics (Schlesewsky & Winter, 2018) show that inequality in Germany has been exacerbated by network changes, causing a loss in welfare. Other studies also conclude that even public subsidies for renewables tend to be more beneficial for wealthy citizens (Andor, Frondel, & Vance, 2015; Borenstein & Davis, 2015). This is a frequently detected negative side effect of incentive schemes (UNU-WIDER, 2017). Consequently, it is necessary to develop fiscal compensatory measures that balance the situation in terms of distributive impacts, while still supporting the changes.

Frondel et al. (2015) specify that prices have doubled in correspondence with the energy transition in Germany, regressively affecting low-income households. Authors

compare the rise in German prices with that of Denmark, where electricity tariffs fund the wind deployment, concluding that prices in the Nordic country are higher. In addition, this work connects the rise in prices and its impact on low-income households with higher social conflicts, supporting the need to design compensatory mechanisms.

Gawel et al. (2015) offer a different perspective and claim that the discussion on energy prices is not deep enough, so the said effects are not as regressive as they seem. They consider that a part of the socioeconomic problem related to the energy transition is a dramatisation of facts: higher prices can be explained through positive energy quality increases.

Apart from Germany and Denmark, the increase in energy prices has also been found in other cases, such as the Netherlands. Bulavskaya & Reynès (2018) conclude, as described previously, a positive effect of the transition on employment and growth due to the higher capital intensity of renewables. Nevertheless, capital intensity is one of the most prominent elements that negatively cause prices to rise.

In France, the cited EUROGREEN model, analyses environment-energy-income dynamics as a matter on its own, i.e., without relying solely on the impact of rising prices as the rest of studies do. In connection with the findings regarding labour, green growth policies amplify income inequalities, while social equity policies and degrowth notably improve equality at the cost of a higher public deficit (incompatible with the EU fiscal guidelines) (D'Alessandro et al., 2020).

In contrast to the European cases, a recent study in the US, focused on wind energy (Mueller & Brooks, 2020), has concluded that there is not a significant distributional injustice regarding income (and race, note that race has not been explored at a European level), but that there is a relevant unfair impact for younger individuals, with lower levels of qualification and labour force participation, especially in rural areas.

2.4.3. Institutional and financial barriers

As this review is focused on labour and income distribution, it is necessary to emphasise that both issues are partly the product of institutional and financial conditions. As found in revisions of historical energy transitions, the evolution of governmental attitudes and their interaction with markets are of a vital relevance to explain the result (Fouquet, 2016). Complementarily, in the review of the present transition, institutional frameworks are of critical importance (Newell & Mulvaney, 2013) along with the financing, as reflected by the recurrence of significant investment and capital variables in empirical analysis. In contrast, institutions and financing tend to be absent in many discussions (Hall, Foxon, & Bolton, 2017). That is why this subsection is specifically devoted to gathering the most relevant institutional and financial factors that could block the path to a successful transition.

As cited, the outcome of the transition on labour is determined by such factors as labour mobility (Bulavskaya & Reynès, 2018), skills and educational training, labour market flexibility, labour intensity (Blazejczak et al., 2014; Bulavskaya & Reynès, 2018; Fragkos & Paroussos, 2018), wage levels (Perrier & Quirion, 2017) and wage elasticity (Bernardo & D'Alessandro, 2016). These variables are the result of public policies and social institutions, such as collective negotiation and sectoral specificities. A labour policy that does not balance flexibility and social protection, as well as an educational system disconnected from the needs of society, are strong barriers to reaching a just energy transition.

Other institutional factors can also be concerned. First, the transnational cooperation providing interconnection between grids and the integration of energy markets (Creutzig et al., 2014). Second, the historical and geographical evolution causing structural differences between territories (Gölz & Wedderhoff, 2018; Markandya et al., 2016). Third, the economic situation and the state of technology determining trade flows (Lehr et al., 2012; Markandya et al., 2016), the production possibility frontier (Fragkos & Paroussos, 2018), as well as capital intensity (Bulavskaya & Reynès, 2018). Fourth, the conditions for funding (Anbumozhi, 2018; Anbumozhi, Kalirajan, Kimura, & Yao, 2016). Fifth, the speed of implementation (Fischer et al., 2016), a variable controlled by policy-makers, but also determined by demand and infrastructures (Smil, 2010b). A set of policies that do not consider the need to strengthen international cooperation or cooperation between administrations (Galgóczi, 2014), or that obviate the diversity of national territories or the macroeconomic consequences of policy timing, as well as an unfavourable economic scenario, barriers for funding or poor financial conditions, could significantly block the proper development of the transition.

Most importantly, beyond institutional factors, there is an undesirable policy outcome that must be warned against and prevented: the negative side effects of subsidies from a distributional perspective (Andor et al., 2015; UNU-WIDER, 2017; Vogt-Schilb & Hallegatte, 2017). Any transition policy that does not contemplate compensatory fiscal mechanisms could be driven to a massive failure.

Other institutional factors, many times forgotten, are social perceptions, information flows, and lobbying practices (Gawel et al., 2015; Groh & Ziegler, 2018), as well as cultural factors (Sovacool & Griffiths, 2019). As stated, social perceptions are of key importance, along with the real effects as measured by the objective indicators. These perceptions are a result of information flows and can be influenced by lobbies and elites whose interests are threatened. Distortions and delays in information flows could also be an obstacle.

Finally, from the financial point of view, one of the biggest concerns is related to the financing of the grid development by electricity consumers (Schlesewsky & Winter, 2018). Under an adaptive market hypothesis, there would be room to identify more structural barriers, pricing mechanisms, market design influence, and behavioural issues in the elaboration of transition policies (Hall et al., 2017).

2.4.4. Classification of reviewed papers considering methodology and results

In Table 2-1, the main empirical studies found to be relevant for this review are classified according to their analytical unit, methodological traits, results, and timing.

Table 2-1 Classification of the reviewed empirical studies

Units	Methods	Methodological traits	Results	Time span	References
World regions	IAM	A human and an earth system are interlinked through land and emissions. It is triggered by such drivers as population, economy, policies, technology, lifestyle and resources to calculate impacts on the environment and development. Limitations: inaccurate monetary feedbacks, calibration distortions in the period 2010-2020, lack of specificity at local and national scales, impossibility of testing specific policies and absence of a governance system.	As labour supply and income disparity via the Gini index are drivers of the model, relying on the definition of scenarios, the interest of this model is the joint consideration of socioeconomic and ecological dimensions in an integrated approach.	1970-2050/2100	Stehfest et al. (2014)
	IAM	It hard-links a macroeconomic (Ramsey optimal growth with equilibrium constraints), an energy and a climate module. Capital, labour and energy are inputs to the model. It includes international trade and investment dynamics. Limitations: lack of detail in processes happening inside world regions, renewable supply intermittence is not detailed, difficulty in capturing efficiency potentials, missing technological spill-overs and stocks of knowledge, lack of constraints in bioenergy.	Since labour is an input, the relevance of the model is the parallel consideration of energy-economy-climate relations in an integrated model with trade and investment dynamics.	2005-2100	Luderer et al. (2011)
	Employment factors	The total employment is calculated as the addition of key jobs during the transition. Energy system transition	Considerable positive effects: renewables contribute to 80% of jobs by 2050 and widely exceed the rate of	2015-2050	Ram et al. (2019)

		model: simulation applied to cost optimality in five-year periods. Innovation: inclusion of energy storage effects.	lost jobs. Higher efficiency, productivity and economic growth. Different impacts across regions, but with a general growth potential.		
	Methodological combinations	As it is a wide-picture report, it combines different methodologies for each topic under focus. It is the only reviewed piece that provides an advanced understanding of gender impacts and an estimation of the effects of climate change combined with the impacts of the energy transition. The relation between decoupling and employment is studied through econometric logarithmic regressions. The resource intensity of employment is calculated by distributing resource consumption equally among all registered employment. The impact of human-induced disasters on labour is estimated by adapting Noy's benchmarking index. The effects of heat stress on workers are calculated by applying grid cell data to population cohorts and employment distribution by sector. The employment balance by sectors, wages, emissions, skills, and gender is estimated with multiregional IOTs.	Net positive effects: declining energy activities will lose 6M jobs, while greening energy activities will generate 24M worldwide. Gender inequality is exacerbated because new jobs are created in industries with higher male-related employment: construction, energy, and manufacturing. Climate change-related natural disasters caused the loss of 0.8% of working time globally between 2010 and 2015. Heat stress will suppose a reduction of 2% in working hours globally by 2030.	1995-2030	ILO (2018)
World countries	IRENA database indicators	Analysis of IRENAS' database historical indicators on renewable energy-related employment by volume, technology, product, gender, and	In 2018, 11M jobs were registered in renewable energy (7% interannual increase), with approximately 33% of them in solar photovoltaic power, 19%	2018	IRENA (2019)

		country. Thus, focused on directly observed records for the energy sector solely.	in hydro, 19% in liquid biofuels and 11% in wind power. 39% of global employment is in China, followed by the EU with an 11% share. By gender, 32% of jobs in renewables are carried out by women.		
Global South country sample	Indicators	Analysis of statistics and estimations from national governments and international organisations. The goal is to study the compliance with SDGs and the potentiality of a just energy transition in a sample of Global South countries.	The South African government estimates 300,000 new jobs in renewables in 2020, but lacks a net perspective. India created 400,000 jobs in 2015 and could create 1M by 2022 relying on wind and solar sources. Rural Vietnam is thought to benefit from decentralised energy technologies (no data provided). Philippines reached 9,700 jobs in bioenergy and 100,000 in the construction of renewable infrastructure in 2015. Morocco has greater exposure to the consequences of climate change. The ratio of employment in renewable vs. conventional plants is 5:1 (no overall data provided). Jamaica created 525 jobs between 2015 and 2017 and could reach 40,000 jobs if performs a complete transition to renewables.	Indicators until 2017 and projections to 2020/2030/ 2050	Hirsch et al. (2017)
US	IAM	Comparison between models. GCAM is a simulation model of partial equilibrium focused on energy and land use that runs in five-year periods.	The interest lies in the comparison of models to strengthen the design and adoption of measures by policymakers. Main insight derived from the	1990-2100	Wilkerson et al. (2015)

		MERGE is an intertemporal optimisation model of general equilibrium based on economic growth and investment, whose time step is ten years. EPPA is a simulation model of general equilibrium centred on the nexus between energy and economy with a five-year step.	comparison: carbon intensities are the source of disparity in comparisons between models. Lack of clear evidence in labour and distributional matters.		
	Regressions	Logistic and Poisson regressions with fixed effects and temporal lags applied to sociodemographic and economic variables regarding the effects of wind energy.	Wind energy has not caused significant injustices in income or ethnicity, but on younger people, with lower levels of qualifications and labour force participation in rural areas.	2008-2017	Mueller & Brooks (2020)
	Econometric model	Parameters are determined by statistical techniques applied to time series. Keynesian background. Demand assumes a higher relevance. Electricity prices are used to generate industrial prices and thus consumption. Employment is a result of output, which is pictured by observing consumption, international trade, efficiency, fuel consumption, and investment. Income is derived from employment and contrasted with consumption. It contemplates the possibility of non-optimality and imbalances in markets. Investment is not totally linked to savings since a stock of capital is available. Only detailed at a European level: the rest of the world is assumed in the 2013 edition (2019 update also includes areas like the US). Limitation:	The application of E3ME to the US context has generated considerably negative impacts of -1.6% in employment and -3.4% in GDP.	2009/2050, 2011/2020, 2009/2050	Lewney et al. (2019)
EU			Small creation of jobs via increasing investment. Biggest positive impact on construction and energy efficiency materials sectors. Jobs will change scope without major changes in skill distribution. Marginal overall changes in jobs, labour rigidity and skill shortages. Labour mobility as a key factor to determine the net effects. Employment net increase of 1.2% due to the fall in oil prices, the increase in investment, the use of public revenues, the loss of jobs in polluting and intensive sectors, and the rise in electricity prices.		Cambridge Econometrics (2013), Lewney et al. (2019)

		not all roadmap technologies were considered.	In the 2019 update, the result is coherent with previous results: an increase of 0.5% is expected in employment and 1.1% in GDP. Investment is again the main cause of this positive result.		
	Econometric model	Macro-sectoral model based on CES production functions. Neo-Keynesian effects have a greater influence. Core model plus four modules. Energy cost affects exports, and thus consumption via competitiveness.	Optimistic consequences. Benefits of an accelerated deployment scenario: 410,000 new jobs and an associated increase of GDP equal to 0.24% in the EU resulting from the total achievement of the 20% renewable energy goal. More ambitious policies could grant a 0.4% increase in the GDP and up to 545,000 jobs in 2030.	1990-2030	Ragwitz et al. (2009)
	IAM	Built on SD. Neoclassical background complemented by demand-side structural change. SD: Nine modules and a connection between demand and supply. Foreign trade is considered and covered. Energy cost is compensated through shifts in marginal consumption that avoids sectors with higher labour intensities.	Pessimistic consequences due to the investment variable and the enhanced impacts of energy cost compensations on labour-intensive sectors: energy costs are compensated for through shifts in households' marginal consumption, subsequently reinforcing the demand for less labour-intensive goods.		
	CGE	Hybrid model: parameters coming from related literature. Neoclassical background: focus on supply and optimality leading to market clearing via prices. Investment is closely attached to savings. Alternative options for users, who can choose some variables.	A small net positive impact is expected despite the scenario. Wage problematic. Results are more pessimistic than in the E3ME model. Substitution and reallocation of jobs constituting around 1% of the total labour force. Final effects depend on the PPF, the prices of primary factors,	2009-2050, 2015-2050	Cambridge Econometrics (2013), Fragkos & Paroussos (2018)

			labour flexibility and intensity. Skill shortages are less important.		
	Indicators	Focused on the energy sector. Contrasts the EU North with the EU South.	Positive effect on energy sector employment found in the literature and up to 1% increase in GDP, favourable to Southern Europe. Rise in prices that affect production and employment in the remaining sectors. Interconnectivity is highly recommendable.	-2050	Creutzig et al. (2014)
	IO	Multiregional to find spill-over effects. No scenarios. Counterfactual method.	Increase in employment after the implementation of sustainability measures (530,000 net jobs, 0.24% in 2009). Exports as a key factor.	1995-2009	Markandya et al. (2016)
Germany	Review, workshops & surveys	Qualitative methodology focused on net employment. The macroeconomic effects are determined by the speed of implementation.	Negative effects of the German energy strategy, especially on employment and equity. Negative impacts on employment and higher electricity prices affecting equity receive more attention from the industry, unions, and governments than from the general population.	2009-2016 and instant data from 2016	Fischer et al. (2016)
	Cost-benefit analysis	Cost-benefit analysis and cost assessment. Solar and wind contrasted. Qualitative, reliant on market argumentation. Focused on electricity.	Most employment is created from investment in installations, but a growing number of jobs are generated in maintenance and services. Employment creation follows geographical patterns and is dispersed. Export markets as a key variable. The distributive effects are unfair from a social perspective (prices have doubled, affecting low-income households, and public subsidies for	2000-2013, 1998-2013, 1990/2010-2030, 2010 vs 2016, 2000-2015, 1998-2015	Andor et al. (2015), Frondel et al. (2010), Gawel et al. (2015), Heindl et al. (2014), Pegels & Lütkenhorst (2014), Schlesewsky & Winter (2018)

			renewables tend to benefit wealthy citizens). Inequality has been increased by network changes, causing a loss of welfare. Regressive effects could lead to social conflict. Failures in the design of the German transition drive some authors to propose greater trust in market mechanisms, although it is not a generalised claim and most of them propose better policies. Those who believe in market mechanisms perceive that previous studies show a dramatisation of facts and price rises are explained because of beneficial quality increases.		
	Econometrics	Econometric analysis of massive surveys.	Perceived distributional effects are key, as are the real effects. Support for the statement which says that those who pollute the most, pay the most. Real burdens are not as high as perceived and are manipulated by elites.	Instant data from 2015	Groh & Ziegler (2018)
	Economic impact assessment	Economic activities connected to physical consumption and energy are unidirectionally soft-linked for each scenario to a macroeconomic model with regional distributions and federal structures.	Overall positive impact on growth and employment, but a problematic geographical distribution of effects. Negative impact on the rise in prices. The construction sector is the winner.	2010 vs 2030	Sievers et al. (2019)
	IO and Econometrics	Neo-Keynesian background considering nominal rigidities, adjustment delays and dynamic error correction. Top-down approach. It contemplates governmental activities	Positive net effect on economic growth boosted by investment. Effects on employment depend on labour flexibility. The restructuration requires a qualification improvement.	2000-2030	Blazejczak et al. (2014)

		and international investment and trade. The model for Germany has been expanded with the use of IO with the specific aim of calculating sectorial impacts. Employment levels are calculated transitioning from gross output to working hours through prices and productivities.			
	IO and Econometrics	Energy-economy-climate econometric simulation model based on IOTs. Bottom-up approach. Limited rationality and non-clearing markets. It considers distribution and redistribution of income, as well as financial agents, and acknowledges international dependencies. It runs in one-year periods.	Net employment will increase, especially from 2020. 150,000 net employments can be created by 2030. Import/export flows are key to determining the result: under decreased levels of renewable energy exports, net levels of employment could be negative (i.e., greater job destruction). The future effect on gross employment will not be as fast as in the past.	2000-2030	Lehr et al. (2012)
Netherlands	CGE	Neo-Keynesian background. Endogenous capital stock and slow adjustment in prices and quantities. It recognises disequilibrium situations. Country-generic.	Positive impact: 50,000 new jobs in 2030 and 1% increase in GDP.	2010-2030	Bulavskaya & Reynès (2018)
Italy	System Dynamics	Lotka-Volterra growth model. Wages and employment are endogenous variables. Long-term horizons are studied based on emissions and GDP variations, while the short-term is analysed in terms of employment and inequalities.	1.2M increase in the number of jobs, pointing to the relevance of the investment variable. GDP falls slightly due to pressure on wages, investment and capital accumulation. It emphasises the link between employment and income distribution and the advantages of System	1970-2030	Bernardo & D'Alessandro (2016)

			Dynamics. The result is determined by wage flexibility.		
France	IO	Data is not updated and missing important events. Inapplicable for several branches.	Results are compatible with those at the European level. The different results between branches are caused by wage levels and the share of labour in added value.	2010	Perrier & Quirion (2017)
	IO and System Dynamics	Country-specific dynamic macroeconomic simulation model. Combination of Post-Keynesian and Ecological Economics backgrounds. Nexus energy-economy-environment. It models an open economy by assuming the rest of the world. Supply is defined through IOTs with endogenous change and technological progress. There are financial constraints for firms. It contemplates three levels of skills, the variation of wages and working time, as well as the effects of automatisation. Inequality is analysed via the Gini index. Households' consumption considers financial variables besides wages and social transfers. It models the public budget balance and recognises the existence of budgetary restrictions. Scenarios: green growth, social equity, and degrowth. Limitations: invariance of technical coefficients of non-energy industries, simplified policy framework, lack of specific technologies for renewable	Under a green growth scenario, unemployment increases 3% by 2050, the Gini index increments by 2.5 points in 30 years, GDP grows by 1%, and emissions equal to 23% of those registered in 1990. The deficit declines and reaches 1.5% in 2050. Concerning policies for social equality scenario, unemployment falls 2% in 2050, the Gini index declines more than 4.5 points and stabilises by 2040, the variation of the GDP and the reduction of emissions are similar to the green growth scenario. Deficit increases up to 4% in 2050 (3% EU limit exceeded). In degrowth, unemployment falls 7% by 2050, the Gini index drops approximately between 6 and 9 points, GDP falls 0.7% by 2050, and emissions equal to 17.8%. Deficit dramatically hikes to 6,5% in 2050 (EU limit notably exceeded).	2014-2050	D'Alessandro et al. (2020)

		sources and storage and absence of climate change-economy feedback.			
Poland	Indicators & factors	Case study that cross-checks the national energy balance and the employment attached to it. The estimation is the result of multiplying energy units by employment factors from national statistics and transition plans, some of which are reused (caution).	Despite the high activity in solid fuels, the variation of employment between the BAU and the transition scenarios is small and can be broken down into two trends: a negative impact on jobs until 2030 and a positive impact from 2030 until 2050. The overall increase is 21% in 2050.	2014-2050	Behrens et al. (2014)
Sweden			Jobs in fossil fuel-related sectors are totally phased out. The creation of green jobs (approximately 120,000 in the energy sector by 2050) is higher than the European average due to a higher renewable capacity.		
Spain			Fast deployment of renewables significantly increases the creation of jobs. However, jobs in primary fuels are expected to increase until 2020, representing 22% of the total estimation. The effects of the economic crisis have affected the potential of renewables to create jobs.		
Catalonia (Spain)	Social metabolism	Multiscale integrated approach. Societal metabolic emphasis. The main mechanism of the model is to check the availability of energy supply to match the requirements of the society for hierarchical levels in each sector. This comparison is subsequently connected to labour. It uses unspecific groups for	Increase in jobs if skilled professionals are available: more than 20,000 jobs in the region by 2020. It could compensate for job losses in traditional sectors and, besides, include a portion of the unemployed population.	2000-2050	Rodriguez-Huerta et al. (2017)

		economic activities and just one scenario is considered.			

Source: Own elaboration.

2.5. Future developments

Current developments inform about an overall positive, yet small, effect on employment levels that is particularly beneficial for the energy sector and construction activities. They also point to a negative impact on income, notably through the mechanisms of prices and the distributive side-effects of subsidies. Nevertheless, the study of just energy transitions has just begun, as seen in Figure 2-1. The review has provided enough information to detect some gaps in the field that would require the implementation of a research agenda.

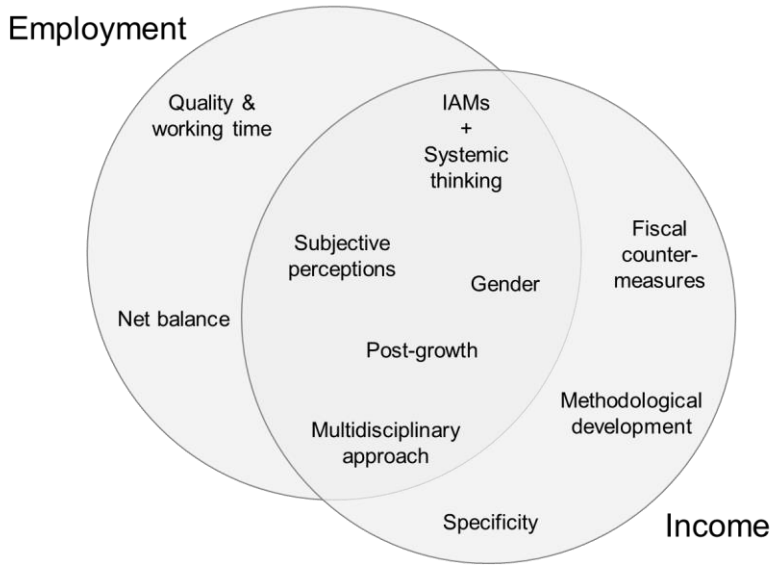
2.5.1. Niches

Based on the previous findings, we have found several methodological gaps, the following being the most notable (Figure 2-8):

- An underdevelopment of methodologies applied to the analysis of income distribution. While relevant advances have been made in the field of labour, income impacts and distribution are delayed. Stronger and more developed methodologies are needed.
- The recurrence of methods that obviate the study of net employment, job quality, and working hours. A problematic reuse of factors has also been found.
- The lack of any consideration of post-growth scenarios in models. While increasing consideration of post-growth has been detected, there is no real translation to empirical analyses.
- The pre-eminence of the German transition in the literature. Germany cannot be used as the default case study, since negative consequences are recurrently detected in empirical studies.
- The almost non-existent mention of the precise consequences of the transition for women. A priori, women could be specifically harmed, so inequalities may not only be neglected, but also exacerbated. Not seeing the gender implications of the energy transition is an analytical bias that cannot be afforded any longer.
- The scarcity of works that aim to analyse the challenge of designing fiscal compensatory mechanisms to correct the negative side effects of incentive schemes, such as subsidies to promote renewable energy.
- The methodological insistence on the advantages of IAMs and systemic analytical approaches, such as SD, in contrast to the absence of studies that aspire to apply them jointly.

- The prevailing use of models that focus exclusively on the energy sector, or that estimate the effect on the whole economy as a consequence of shifts in the energy sector. These studies also show a narrow perspective, limited to their academic area.
- The generalised consideration of registered data as the only elements that economic agents use to make decisions, without considering the role that subjective perceptions play as a result of information flows and stakeholders' views.

Figure 2-8 Methodological niches in the field of just energy transitions



Source: Own elaboration.

These gaps evince a significant disconnection between the institutional framework and the methods used by scholars, and between scholars' theoretical considerations and their final empirical applicability. Consequently, there is a need to specify a research agenda to orientate this thesis and future works.

2.5.2. Research agenda

To overcome these limitations, we propose the following research agenda to be developed in future works:

- High priority tasks: short to medium term.
    - *Increase the efforts put into the research of income levels and distribution*. It must be considered as a matter on its own, rather than a problem exclusively linked to the consequences of labour shifts or the rise in energy prices.

- *Widen the variety of methods applied in the case of labour*. Research should aim to capture the big picture and focus on the net employment balance and widen the knowledge of job quality and working time variations. The reuse of employment factors should be prevented.
- *Introduce the possibility of controlled degrowth in models away from the predominant growth paradigms*. Both growth and degrowth should be considered to test the models and political outcomes. Otherwise, the modelling is biased towards growth preferences.
- *Enlarge the number and type of geographic units proposed*. In this regard, we propose the Nordic countries as a possible case instead, especially Sweden and Denmark, as well as local rural areas.
- *Start considering seriously the gender dimension in the energy transition, following the recommendations from the ILO*. In the process of calculation, a disaggregation of workers should be done according to their gender, so negative impacts on women's labour can be detected, as well as testing the effects of equality policies on a transition scenario (for instance, family reconciliation concerning the variation of working time).

- Medium priority tasks: medium to long term.
  - *Explore the possibilities for modelling techniques that hybrid IAMs and SD offer, especially when applied jointly*. There are still many methodological borders separating them; the categorical classification discussed being a proof. As long as a joint application of methods serves to reinforce the strength and consistency of the analysis, it is an interesting exercise to progressively blur such borders.
  - *Broaden the scope of models and estimate the effects of the energy transition in the economy*, developing a more solid macroeconomic base, directly sector by sector, rather than solely focusing on the energy sector or studying the diffusion from the energy sector to the rest of the economy. Models with diverse thematic modules relying on transdisciplinary fields could be a methodological possibility to explore. Besides, there is a need to deepen our knowledge on fiscal compensatory mechanisms.

- *Developing techniques that allow researchers to consider citizens' perceptions along with real data in models*. Even though research must be built on verifiable available data, citizens, who are the principal agents and the main recipients of costs and benefits, do not consider this kind of data continuously, but rely more on perceptions. Perceptions are not as easily suited to modelling as real data. However, a growing consideration should be given to this aspect, to understand the ultimate underlying reality on a social level.

2.6. Conclusions

The global environmental and human crisis has led to the renaissance of just transitions, this time centred around the shift to a sustainable energy mix. This renewed notion of just energy transition, which has transcended its origin in the US union movement of the past century, has been sponsored in the framework of the Sustainable Development Goals by the International Labour Organisation. The ILO has stressed both sides of the transition: the one where the transition creates net employment, improvements in the quality of jobs and a reduction of poverty; and the dark side, where the transition implies costly socioeconomic restructuring and regressive political effects, while facing the bill of climate change adaptation.

This systematic review has revealed some key insights into the methodological approaches in the field.

First, the diversity of methods has motivated some restrictive classifications in previous studies that must be observed with caution and an open perspective, since these classifications have been surpassed by the empirical state-of-the-art. Empirical analyses are blurring the lines between methods and generating methodological combinations. Notwithstanding, there is a notable preference for CGE models and IAMs based on IOTs. This review has detected a growing interest in hybrid approaches, that combine top-down and bottom-up modelling, as well as interest in systemic modelling techniques such as System Dynamics. There is also a pre-eminence of case studies focused on the research of impacts at a national and regional level, many times with a comparative ambition. Lately, regional levels are gaining momentum to determine asymmetric consequences among territories.

Second, there is a scarcity of works devoted to the distributional consequences of the transition and an underdevelopment of methodologies in comparison with the abundant literature and advanced methodology found in the case of labour. Besides the lack of synchronisation between the two topics, both have been primarily analysed through a linear and unidirectional perspective; while in fact, the transition is a complex,

multidimensional and multidirectional phenomenon. Likewise, many studies have put their efforts into estimating direct gross impacts on employment levels, when the focus to assess the just transition should be on direct, indirect and induced net volumes. Even if this misconception of employment balances has been increasingly prevented, most studies are blind to impacts beyond volumes, such as the quality of jobs, the variations in working hours and the gender balance of the transition. These absences evince the disconnection between the institutional approach, reflected by the ILO, and the academic approach, and also between scholars' theoretical considerations and their final empirical applications.

Third, the key variables identified in the literature to determine the outcome of the transition are the timing/speed of policy implementation, investment, international trade, the production possibilities frontier, the prices of primary factors, labour flexibility and intensity, and the elasticity of wage levels. Studies generally find a positive, yet relatively small, impact on employment levels, led by the construction, manufacturing, and energy sectors, in conjunction with a negative distributional effect caused by rising electricity prices as a result of network developments and the regressive side effects of public subsidies. Neoclassical models have reached less optimistic results than other methodological backgrounds and tend to emphasise the role of investment and wage levels, while relegating skill shortages. Methodologies relying on surveys and workshops highlight the negative distributional effects with more intensity. This result points to the necessity to consider perceptions alongside real data in the assessment of the transition.

In the light of these conclusions, we propose a research agenda that underlines the need to make greater efforts in the study of income dynamics, the effects on job quality and working hours and the role of supporting such policies as compensatory fiscal mechanisms, specifically considering the precise impact of the transition pathways on women. There is also a need to introduce post-growth scenarios in the models to complement green growth strategies and to broaden the geographic scope being researched: instead of Germany, that monopolises the available literature, it would be enriching to consider the Nordic countries, especially Sweden and Denmark, due to their institutional backgrounds, as well as other scales like the local ones.

As the methods, results and research gaps in the literature have been disclosed, we proceed to analyse our case study in the next Chapter.

Chapter 3

THE JUST ENERGY TRANSITION TO RENEWABLES IN MINING AREAS: A LOCAL SYSTEM DYNAMICS APPROACH

The literature review in the previous Chapter indicates a prevalence of quantitative approaches, notably modelling, applied to global and national scales. The prevalence is probably justified based on the need to quantify impacts, the global nature of environmental matters, and the leadership of national scales in fixing energy and climate targets.

This prevalence, which has contributed to shaping the state-of-the-art and providing the commented insights, has relegated local scales to a secondary position. Following the common structure, studies consider that any sub-national scale is local. Considering the territorial structure of our close context, local can refer to the regional entities, the provinces, and even the municipalities. Among them, the smallest local realities have been particularly neglected, specially from the viewpoint of quantitative assessments due to some methodological barriers that seem uncrossable.

This gap is clearly relevant in the Spanish case. The central government has launched public interventions under the precise umbrella of the just energy transition that has coincided with the development of this research work. In the Spanish strategy, municipalities are the basic unit of governmental coverage and intervention. Most of the municipalities are rural, as happens in León, which congregates most of the interventions at a regional and national scale.

Hence, given the near experience with just energy transition that is currently unfolding, this thesis suggests analysing the process to extract lessons to correct the ongoing processes and inspire other processes in declining fossil-dependent areas. As far as the gap in quantitative approaches is concerned, we aim at contributing to designing intuitive and affordable tools for a vast diversity of stakeholders and minimising barriers such as data availability. In consequence, this Chapter aligns with the second secondary goal of the research, "to analyse the most recent proposals for a just transition of the areas under study and determine the strengths and weaknesses of public plans, as well as to offer quantitative insights into the development of the restructuring to find the priorities of future political agendas and stakeholders' action". Furthermore, it is addressed to complete the information required to test the first hypothesis, i.e., determine the sign of

the impacts of the energy restructuring, in combination with the insights derived from the review.

The following Section 3.1 draws a contextualisation in political-normative and socioeconomic terms of the case of León. Section 3.2 presents the strategical advantages that the Leonese case offer to capitalise on the just energy transition, regarding climate and orography, technology and infrastructures, as well as education and human skills. Section 3.3 introduces the quantitative methodology in detail, attending to both the modelling precedents, our proposal, and data sources. Section 3.4 discloses the scenarios and results of the simulations. To complete the case study, Section 3.5 introduces a commentary on the political plans in the light of the insights derived from the study of just energy transitions along the research. The commentary follows three lines: concept and design of the plans, diagnosis, and processes of public participation. Section 3.6 derives the conclusions.

3.1. Contextualisation

This brief contextualisation covers the political-normative context and the socioeconomic context. Both aspects are needed to design a realistic model.

3.1.1. Political-normative context

The processes of just energy transition in León are built over a wide political-normative framework, in which every administrative level has provided its own goals and regulations to develop the global core principles of the SDGs and the ILO.

At a European level, there is the 2030 Climate & Energy Framework (European Commission, 2014), updated with the European Green Deal in 2020 (European Commission, 2020a) and the Mechanism of Just Transition (European Commission, 2020d). The updated Framework, which receives the main consideration in national strategies, fixes the three main European goals: a 55% reduction of GHG (referenced to 1990), the presence of at least 32% of renewable sources in the energy mixes and the improvement of energy efficiency by 32.5%. The Mechanism of Just Transition is aimed at alleviating the socioeconomic impact of the energy rearrangements in the most affected regions through the investment of EUR 150 M between 2021 and 2027 (European Commission, 2020c) based on three pillars: the Just Transition Fund, InvestEU "Just Transition" and the loans of the European Investment Bank.

At a national level, Spain has elaborated the Strategical Framework of Energy and Climate, which consists of three elements: the National Integrated Plan of Energy and Climate, the Law of Climate Change and Energy Transition and the Strategy of Just Transition. Regarding this Strategy, the government has set up a Plan for Urgent Action in Coal Mining Municipalities and Centrals in Closure 2019-2021, as well as a system of

Agreements of Just Transition ("Convenio" in Spanish or "CTJ") (Ministry of Ecological Transition and Demographic Challenge, 2020f).

CTJ are the main tool to accomplish the Strategy in Spain. They are focused on the zones that are affected by the cease of mining, thermoelectric or electronuclear activities and pursue the creation of jobs through the use of local resources and the attraction of investments. Their elaboration begins with a report of "Delimitation, Characterisation and Diagnosis", which determines both the territorial borders of the CTJ and the sociodemographic and economic situation of the area and proposes an analysis of Strengths, Weaknesses, Opportunities and Threats (SWOT). This diagnosis is then sent to the stakeholders of the area with a questionnaire to evaluate it and is also reviewed by external auditors. Afterwards, the Institute elaborates a second report including the answers obtained in the questionnaires and organises a technical conference, i.e., a group of workshops in which stakeholders are asked to participate to present and discuss the conclusions. With this information, the initial report is revised to concretise the lines of action.

CTJ take the municipality as the basic territorial unit and the affected employment as the main criterium of inclusion in the coverage of actions, quantified in the worst-case scenario and subject to additional corrections of coherence and territorial cohesion (Ministry of Ecological Transition and Demographic Challenge, 2020i, 2020j, 2020h, 2020l, 2020k). To decide the inclusion or exclusion of a municipality in the coverage of a CTJ, the Institute applies the following steps (Figure 3-1):

- First, there is the need to identify the affected installations and the municipality in which they are located. These are immediately included in the area of coverage.
- Afterwards, there is a quantification of the affected workers, both own and outsourced, a determination of the municipalities where they live and a calculation of the impact of their unemployment referenced to the local working-age population. If the impact on the municipality is greater than the mean of all municipalities where the affected workers live, the municipality is included in the coverage zone, as long as it belongs to the autonomous community of the CTJ. At the end of this process, at least 85% of the affected workers must be gathered by the executed municipal selection.

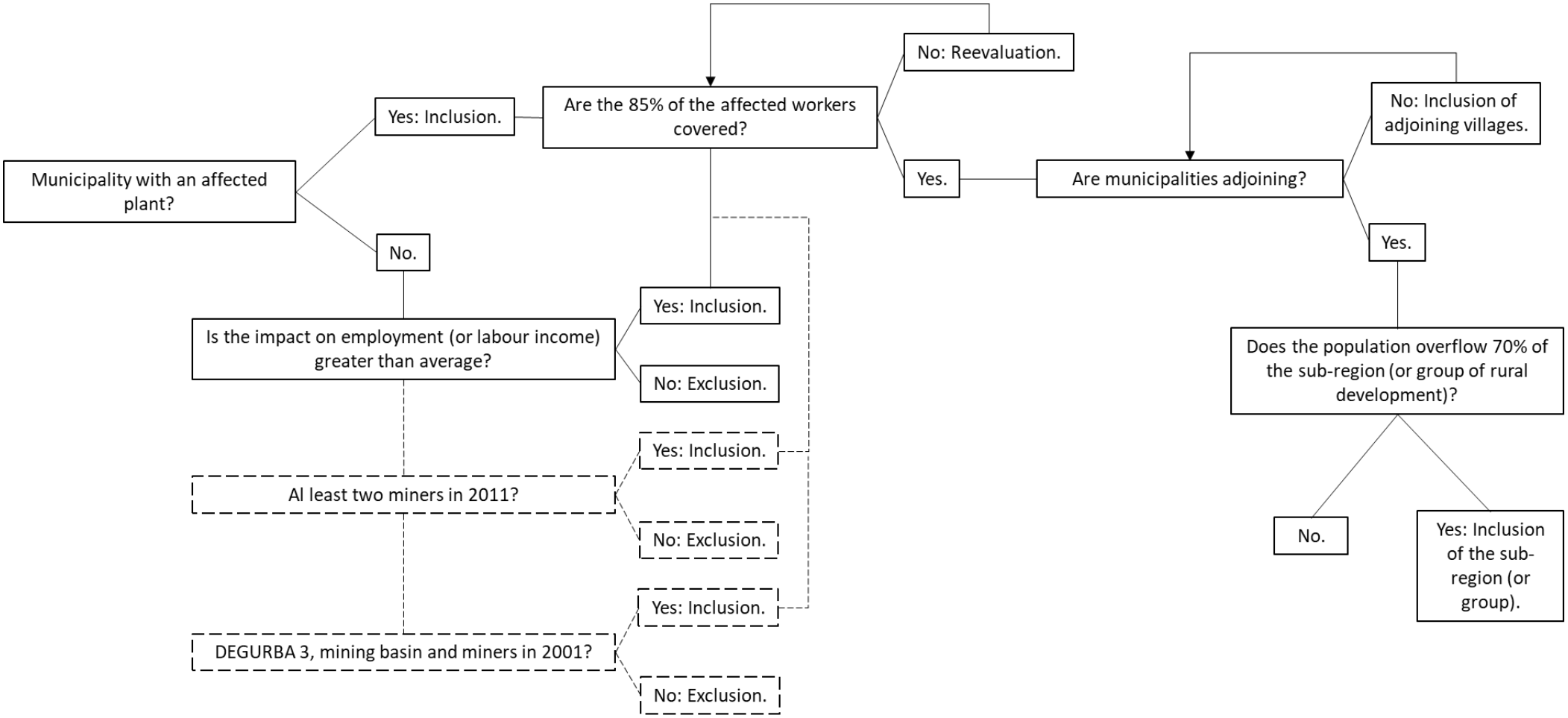
  After the phase of public participation and audit, the Institute has additionally introduced the impact on labour income, as an analogous criterium to that of impact over employment (Ministry of Ecological

Transition and Demographic Challenge, 2020e, 2020d, 2020a, 2020c, 2020b).

- Finally, there is the application of the criteria of territorial coherence and cohesion, which are motivated by three requisites: geographical continuity, respect for the sub-regional (in Spanish “comarcal”) structure and belonging to the groups of rural development. The first establishes that the selected municipalities must be adjoining. The second and the third determine the inclusion in the CTJ of a sub-region (or group of rural development) if the population of the municipalities that have been selected under the criteria of impact overflows 70% of the population of the sub-region (or group).

Again, after the phase of public participation, two additional criteria have been introduced. First, the inclusion of those municipalities where at least two miners of coal were present in 2011. Second, the inclusion of those strictly rural municipalities (DEGURBA 3) that belong to the mining basin where mining workers were present in 2001.

Figure 3-1 Diagram of decision for the inclusion of municipalities in the CTJ



Source: Own elaboration.

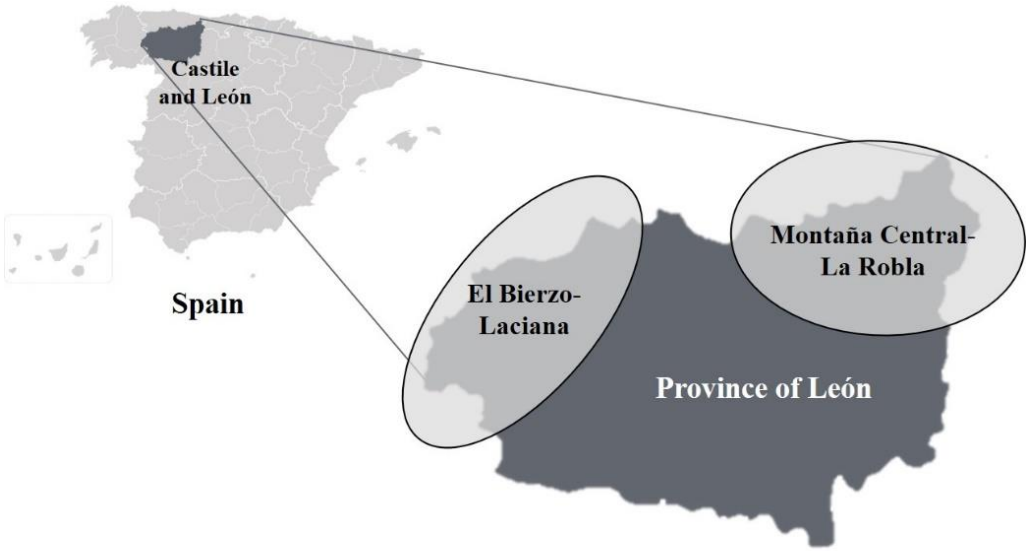
Additionally, the MITECO and the Ministry of Labour and Social Economy have set up a dialogue with the mining sections of unions and business associations, called the "Tripartite Social Dialogue" (Pérez Díaz & María-Tomé Gil, 2020). As a result, they have launched an "Agreement for a Just Transition of the Coal Mining and a Sustainable Development of the Mining Subregions, 2019-2027" and an "Agreement for a Just Energy Transition for Thermoelectric Plants in Risk of Closure: Employment, Industry and Territories". In parallel, the two Ministries provide the capacity of the Public Employment Service (SEPE in Spanish) to educate and ease the insertion of the affected workers, through complete education, upskilling or reskilling programmes. For its part, business associations have compromised to elaborate proposals of substitution of the mining activities, and unions have compromised to follow the progress made, accelerate education, promote occupational safety and disseminate the projects of transition.

At a regional level, the Council of Castille and León is elaborating the Law of Climate Change and Energy Transition, with a Strategy of Renewable Thermal Energy and Energy Efficiency. Likewise, there is a Plan under execution to Dynamise the Economy of Mining Municipalities through an investment of EUR 3.6 M to facilitate the employment of affected workers in León (and also in Palencia) who have a special difficulty being hired due to their sociodemographic profile or status, therefore generating an impact of 340 jobs.

3.1.2. Socioeconomic context

The diagnosis carried out by the CTJ in León draws its particular socioeconomic status based on seven indicators: depopulation, dependency, ageing, working-age population, registered businesses, jobs at risk at the closure of plants, and the local budgetary effect of the cease of activities through the corresponding taxes on property (IBI) and economic activities (IAE) (Ministry of Ecological Transition and Demographic Challenge, 2020i, 2020j, 2020h, 2020l, 2020k). After the process of revision, the Institute has included pyramids of population, with wider ratios (from 2002 instead of 2009) of childhood, youth, ageing and masculinity, as well as the dispersion of the population, the gross annual income, the disposable gross annual income, land uses, the register of facilities for tourism, the availability of communication technologies, protected natural locations, geographical indications and traditional specialities (Ministry of Ecological Transition and Demographic Challenge, 2020e, 2020d, 2020a, 2020c, 2020b). This diagnosis was elaborated before the COVID pandemic, with a notable demographic and economic impact. Consequently, we have updated the available indicators by the end of 2020 (INE, 2021b, 2021a) for the areas of just transition (Figure 3-2) in Table 3-1.

Figure 3-2 Location of the province of León in Spain and the areas of just transition in the province



Source: Own elaboration.

Table 3-1 Main indicators of the socioeconomic context in comparison with the province and the autonomous community

Indicator	C&L	León	CTJ El Bierzo-Laciana				CTJ Montaña Central-La Robla
			Fabero-Sil	Bierzo Alto	Laciana-Alto Sil	Cubillos Sil-Ponferrada	
Var. population (1996-2020)	-4,53%	-11,75%	-31,54%	-29,49%	-43,83%	5,01%	-34,47%
Var. dispersed population (2000-2019)	-	-20,77%	-10,84%	-23,99%	-13,95%	-9,15%	-22,27%
Index of chilhood (2019)	11,86%	10,59%	6,90%	8,16%	7,28%	11,97%	7,13%
Index of youth (2019)	13,09%	12,30%	12,06%	12,59%	11,56%	13,13%	10,86%
Index of ageing (2019)	213,84%	255,37%	418,49%	352,75%	392,36%	196,86%	461,07%
Var. gross income per capita (2013-2017)	5,03%	3,42%	2,64%	3,75%	1,92%	6,47%	5,39%
Var. disposable income per capita (2013-2017)	6,15%	4,44%	4,14%	4,73%	3,90%	6,96%	6,84%
Var. working age population (2009-2018)	-4,19%	-3,69%	-3,36%	-3,70%	-2,42%	-4,61%	-2,90%
Unemployment rate (2019)	11,19%	12,99%	17,85%	14,01%	11,56%	17,23%	14,34%
Var. registered businesses (2012-2020)	-2,91%	-4,78%	-4,59%	-8,16%	-3,47%	-5,54%	-12,18%
Direct impact over working age population (2020)	-	-	2,45%	0,41%	0,53%	0,50%	1,63%
Affected local public budget	-	-	46%	-	-	61%	31%

Source: Own elaboration based on INE (2021 a, b) and MITECO (2020 a, b, c, d, e, f, g, h, i, j, k, l). The councils that serve as references for the local public budget are: Páramo del Sil in Fabero-Sil, Cubillos del Sil in Cubillos Sil-Ponferrada, and La Robla in Montaña Central-La Robla. Effects are calculated in fiscal years 2017/2017, 2017/2017 and 2018/2020, respectively.

These indicators illustrate that the cease of coal has aggravated locally the processes of depopulation, ageing and dependency that the province and the community also suffer. The evident exception to this behaviour is located in the area Cubillos del Sil-Ponferrada, which largely improves the situation of the province due to the influence of Ponferrada, a diversified and larger town that has acted as a pole of attraction of population during the decline of mining.

Montaña Central-La Robla displays the greatest reduction of registered businesses. In contrast, Laciana-Alto Sil has destroyed the industrial network at a slower pace in comparison with the province.

Regarding the jobs at risk at the moment of closure, the impact is more intense in Montaña Central-La Robla and Fabero-Sil. This effect from a fiscal perspective is notable in the case of Cubillos del Sil, where 61% of the public budget is lost.

3.2. Local strategical advantages to foster a just energy transition

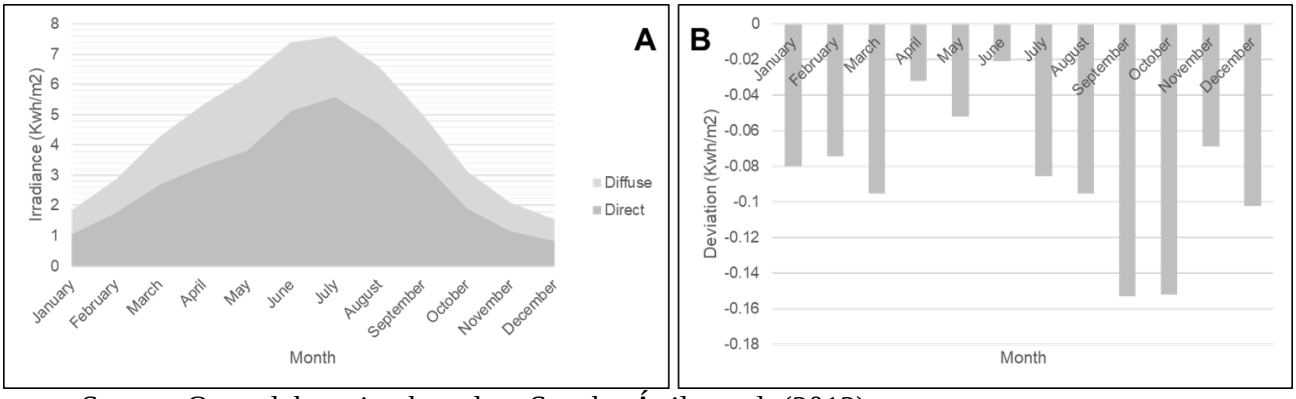
To tackle this situation of socioeconomic deterioration, León presents some elements of strategic relevance to secure the success of the just transition, due to its climate and orography, its technological capacity and availability of resources, with special mention given to professional skills.

3.2.1. Climate and orography

Recent studies point to León as a strategic location for solar photovoltaic (PV) as it would be the most profitable province in the community for recouping the investment in this technology (5.4 years) (Pérez Díaz & María-Tomé Gil, 2020; Sotysolar, 2020). This result is however negligible to our analysis for generalising to the province the average insolation (2,727 hours), including southern and eastern areas, plainer and lower, which generate a climate of transition. The areas of the CTJ present higher cloudiness and rainfall because of the proximity of the Atlantic Ocean combined with the altitude, which generates oceanic and high-mountain climates.

Besides this generalisation, there is another constricting element: a solar irradiance (Figure 3-3 A) below the community average, notably by the end of summer and the beginning of autumn, although such a divergence softens by the end of the spring and the beginning of summer (Figure 3-3 B) (Sancho Ávila et al., 2012).

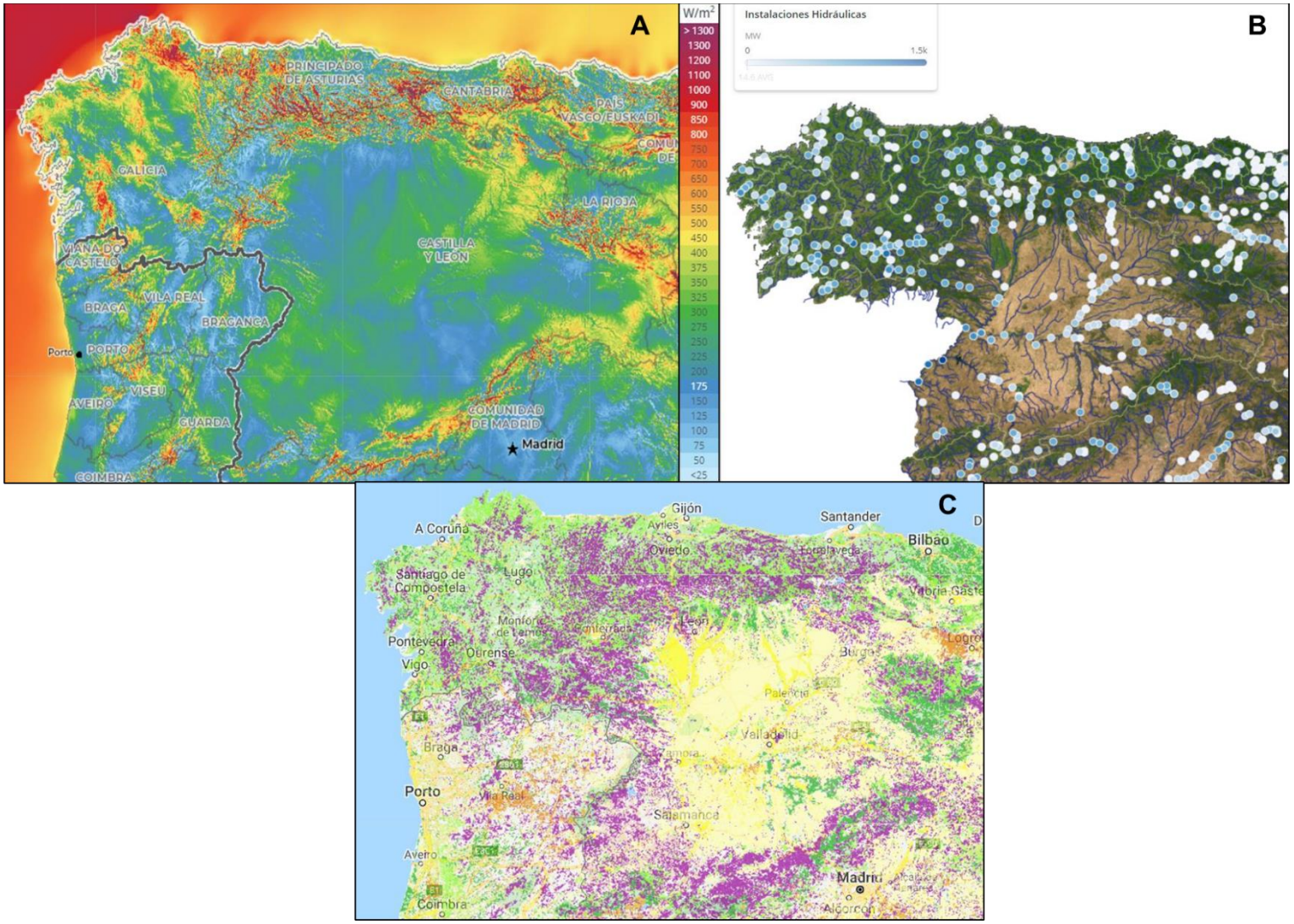
Figure 3-3 Direct and diffuse monthly irradiance (KWh/m^2) in León (Panel A). Monthly deviation of the total irradiance in León referenced to the community average (KWh/m^2) (Panel B)



Source: Own elaboration based on Sancho Ávila et al. (2012).

The evident strategical advantage is wind power: the orography and localisation of the affected areas provide wind resources of superior quality. The average wind density at 100 meters in 10% of the windiest areas in Spain is 717 W/m^2. Many locations in the areas of the CTJ are significantly above the average, with registers around 1,000-1,300 W/m^2 (Figure 3-4 A) (DTU, 2019).

Figure 3-4 Average wind density (W/m^2) at 100 meters in the peninsular North-West (Panel A). Localisation and capacity (MW) of hydropower plants (Panel B). Potential availability of residual biomass, from forests (green-yellow) and agriculture (yellow-orange) (Panel C)



Source: A: DTU (2019). B: REE ESIOS (2021) on Carto. C: CIEMAT (2021) on Google Maps (2021).

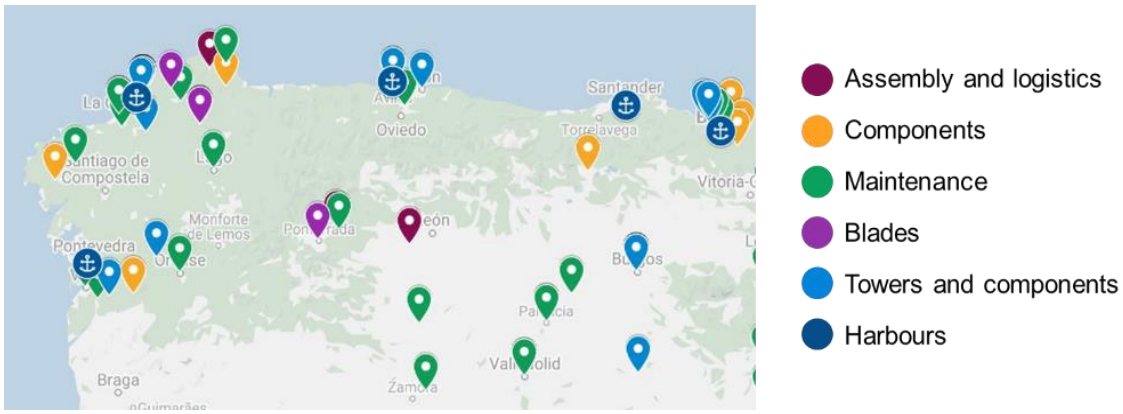
The orography and climates also incentivise the deployment of hydropower and biomass. The affected areas already record an outstanding presence of hydropower plants (REE ESIOS, 2021) that take advantage of gradients in the land to produce electricity with a higher power than most of the remaining installations in the community (Figure 3-4 B).

Concerning biomass, the affected areas have an elevated residual availability, mainly of a forest origin. Residual agricultural biomass is placed in the surrounding areas (Figure 3-4 C) (CIEMAT, 2021). León stands out in the production of biomass pellets with 39,526 metric T per year (18% of the community) and two certified distributing enterprises (Avebiom, 2020a, 2020b). This business presence is unusual, especially in provinces with the characteristics of León.

3.2.2. Technological capacity and infrastructures

León has more industries for the production of wind technologies and a more diversified typology than any of the remaining provinces in the community (AEE, 2020). In Ponferrada (area Cubillos del Sil-Ponferrada), LM Wind Power produces blades, control systems and pitch systems; Bembibre (area Bierzo Alto) is the headquarters of Vestas Eólica SAU for the maintenance of wind turbines; San Román de Bembibre has four centres of Indra System for support, engineering and maintenance; and Villadangos del Páramo (half-way between the CTJ areas), a centre for the assembly and logistics of nacelles in Bach Composite. The platforms for blades and assembly are unique in the community, as well as in Asturias and the East and Center of Galicia (Figure 3-5).

Figure 3-5 Wind power intermediaries and enterprises in north-western Spain



Source: AEE (2020) on National Geographic Institute-Google Maps.

Likewise, León also has two European Projects of Common Interest (PCI) about the storage of electricity by hydro bombing (European Commission, 2020b). These are the installation of the Reversible Central Water Treatment Plant in the River Cúa (area Fabero-Sil), expected for 2028, and the Plant P-PHES Navaleo-CDR Tremor near Bembibre (area Bierzo Alto), expected for 2024.

Finally, the logistic potential of the province, and especially the affected areas, derives from their geographical location and degree of development of road and rail infrastructures. Bierzo-Laciana is the connection between the community and Galicia and Montaña Central-La Robla with Asturias. Considering railway connections, they display a relevant role in the communication with the North of Portugal, as a key intermodal nexus (Castile and León Regional Council, 2018). León has the potential to augment its relevance in the Atlantic corridor, with a continental repercussion in process of expansion through the European Commission's Programme "Connect Europe". With this expansion, the affected areas would be vital points in the new South-West zone of the corridor.

3.2.3. Education and skills

The transition demands qualified workers in skills that are increasingly more advanced. Academic training is vital for the development of such skills. CTJ take as an indicator the level of education of the inhabitants of the areas according to their branches of specialisation in 2001 and 2011 (census) and reflect a progression towards superior studies. In Montaña Central-La Robla (Ministry of Ecological Transition and Demographic Challenge, 2020e, 2020l), Laciana-Alto Sil (Ministry of Ecological Transition and Demographic Challenge, 2020d, 2020k) and Bierzo Alto (Ministry of Ecological Transition and Demographic Challenge, 2020a, 2020h), most of the citizens with completed studies have received training in technical disciplines as a consequence of the specialisation in mining. Bierzo Alto overflows in technical training the figures of the province and the community. In contrast, Social Sciences and Law prevail in Fabero-Sil (Ministry of Ecological Transition and Demographic Challenge, 2020j, 2020c) and notably in Cubillos del Sil-Ponferrada (Ministry of Ecological Transition and Demographic Challenge, 2020i, 2020b), due to their diversification towards services.

In this thesis, we additionally focus on education centres that provide studies in the levels three and superior of the European Qualifications Framework (EQF), i.e., secondary education, vocational training, and universities, due to their role in the process of training future workers.

Currently, Fabero-Sil and Bierzo Alto have three centres for secondary education, two for baccalaureate and one for vocational training, and Laciana-Alto Sil has two centres for secondary education, two for baccalaureate and one for vocational training (Ministry of Education and Vocational Training, 2021). The prominent case is Cubillos del Sil-Ponferrada: its dimensions and diversification allow the presence of nine centres for secondary education, six for baccalaureate and four for vocational training, with the capacity to attract students from the remaining areas. Montaña Central-La Robla has four centres for secondary education, two for baccalaureate and one for vocational training (Table 3-2).

Table 3-2 Education centres in EQF 3-5 in the affected areas

CTJ and area		Sec.	Bac.	Voc.
CTJ El Bierzo-Laciana	Fabero-Sil	3	2	1
	Bierzo Alto	3	2	1
	Laciana-Alto Sil	2	2	1
	Cubillos Sil-Ponferrada	9	6	4
CTJ Montaña Central-La Robla		4	2	1

Source: Own elaboration based on the Ministry of Education and Vocational Training (2021).

Vocational training has a special interest because it provides applied skills in the precise affected areas through vocational training branches that are essential for the transition (Table 3-3). Ponferrada plays a key role as it has exclusivity in the branches of Edification and Civil Works and Installation and Maintenance, while Laciana-Alto Sil stands out for having the only title in the branch of Social and Cultural Services for the Community (in this case, care of dependent people) (Castile and León Regional Council, 2020).

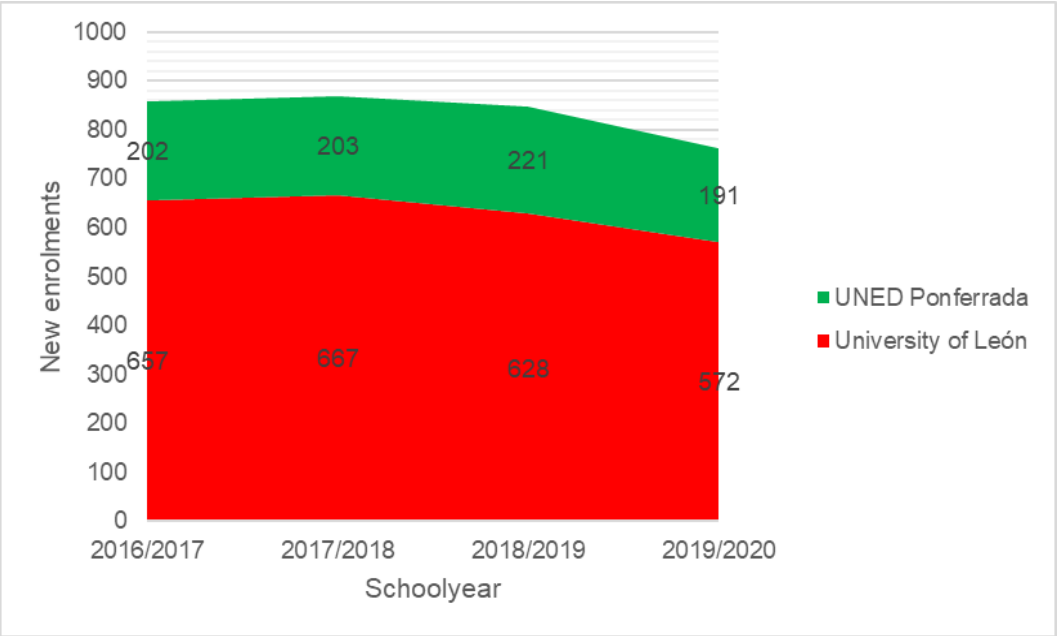
Table 3-3 Available in-person places by essential vocational training branch for the transition and CTJ/area in schoolyear 2020/2021

Vocational branch	CTJ El Bierzo-Laciana				CTJ Montaña Central-La Robla
	Fabero-Sil	Bierzo Alto	Laciana-Alto Sil	Cubillos Sil-Ponferrada	
Edification and Civil Works	0	0	0	47	0
Electricity and Electronics	0	0	0	197	38
Mechanical Manufacturing	0	0	45	51	76
Computing and Communications	41	0	0	96	43
Installation and Maintenance	0	0	0	85	0
Social and Cultural Services	0	0	46	0	0
Transportation and Maintenance of Vehicles	0	125	0	88	0
TOTAL	41	125	91	564	157

Source: Own elaboration based on Junta de Castilla y León (2020).

In EQF levels superior to five, León has two Universities that are well-rooted in the two areas in transition. The University of León (ULe) has two campuses: the main in the capital, 20 Km away from the CTJ area of Montaña Central-La Robla and the second in Ponferrada, in the priority area of Cubillos del Sil-Ponferrada. The National University of Distance Education (UNED) has its main centre in Ponferrada, with associated classrooms in the priority areas of Villablino (Laciana-Alto Sil) and Vega de Espinareda (Fabero-Sil). These campuses welcome hundreds of students in key studies for the transition: Environmental Sciences, Food Sciences, Geography, Engineering, Labour Relations and Human Resources, Social Work and Tourism (Figure 3-6) (National University of Distance Education, 2021; University of León, 2021).

Figure 3-6 New enrolments in essential undergraduate studies for the transition, schoolyears 2016/2017-2019/2020



Source: Own elaboration based on ULe (2021) and UNED (2021).

Once we have delimited the process of transition, both from a political-normative and socioeconomic context, and detected the strategical advantages in the case, we are in disposition to design the model. This attempt is innovative in the field of just energy transitions. As found in the literature review (Chapter 2), national scales have recurrently led the topic, mainly from quantitative perspectives grounded on national accounts and IOA. In the past years, regional approaches have also increased their popularity to illustrate the asymmetric effects of the processes (Gambhir et al., 2018). Contrariwise, local energy transitions, i.e., those at a sub-national level (Selvakkumaran & Ahlgren, 2018b), have been relegated to a secondary position.

3.3. Methodology

The analysis of the socioeconomic impacts of energy transitions tends to congregate its efforts around modelling (Hardt & O'Neill, 2017; Rosebud Lambert & Pereira Silva, 2012). Modelling, complex per se given the intertwines between the matters that we are dealing with, notably restricts its application to world, national, and regional scales (Gambhir et al., 2018). In consequence, few attempts to test local energy transitions have been produced through modelling. This scarcity is understandable if we jointly picture the complexity of models and the scarcity of valuable and accurate data at such a small scale.

3.3.1. Modelling precedents

The scarcer literature about local scales tends to circumscribe to qualitative approaches, to the extent of considering local studies as strictly initiative based learning literature (Turnheim et al., 2015). Selvakkumaran & Ahlgren (2018b) demonstrated the relevance of quantitative techniques in local cases, yet dominated by the socio-technical theories of Strategic Niche Management or SNM (Coenen, Raven, & Verbong, 2010; Hoppe, Graf, Warbroek, Lammers, & Lepping, 2015; Seyfang, Hielscher, Hargreaves, Martiskainen, & Smith, 2014) and Multi-Level Perspective or MLP (Beermann & Tews, 2017; Fallde & Eklund, 2015; Fudge, Peters, & Woodman, 2016). Regarding SNM, Coenen, Raven & Verbong (2010) performed a qualitative dissertation, while Hoppe, et al. (2015) settled this theory through a quantitative analysis based on qualitative data from interviews to illustrate the relevance of the mentioned theory in combination with the leadership of public officials and community trust. Seyfang et al. (2014) insisted on the role of mutual trust after exploring the functionality of networking and intermediary organisations in the British community energy sector. Among the works aligned with MLP, Beermann & Tews (2017) showcased an empirical analysis, both based on objective indicators and results from surveys, to analyse the new role of decentralised renewable capacities after institutional shifts and the progress of the transition, therefore pointing to the need of greater systemic coordination. Fallde & Eklund (2015) captured the intertwines between the support from national levels and the leadership of local actors in the development of sustainable projects in municipal transportation. For their part, Fudge, Peters & Woodman (2016) identified through qualitative data from interviews possible specific factors to link local and macro goals in the British context.

These papers, as observed by Selvakkumaran & Ahlgren (2018b) in their review, tend to explain and theorise past events as an extension of general transitions, a posteriori, without the needed specificity and emphasis on complex dynamics. This specificity of local energy transitions lies on five issues according to these authors: spatial scale, ownership of the transition, differing priorities among stakeholders, different institutional structures, and situative governance issues.

Regarding the range of quantitative methods, local cases have increasingly applied SD to model transitions because of its ability to allow systemic thinking, connect these specificities and bridge complex multidisciplinary issues (Selvakkumaran & Ahlgren, 2020). As disclosed in the literature review, systemic thinking is a widespread claim in just transition studies (Finley-Brook & Holloman, 2016), a research gap, and consequently, one of our proposals in the research agenda (Section 2.5). Such methodology has been more frequently employed to analyse local energy transitions than any other local socio-technical transformation. It has covered the electricity sector itself (Agnew, Smith, & Dargusch, 2018; Capelo, Ferreira Dias, & Pereira, 2018; Castaneda,

Franco, & Dyner, 2017; Kubli & Ulli-Beer, 2016; Liu et al., 2018; Pruyt & Thissen, 2007; Selvakkumaran & Ahlgren, 2018a) or in combination with other sectors (Blumberga, Timma, & Blumberga, 2015; Hollmann & Voss, 2005; Matthew, Nuttall, Mestel, & Dooley, 2017; Pruyt, 2011), as well as the full energy sector and its relationships with non-energy sectors (Brouwer et al., 2018; Zhao et al., 2018).

Yet, these local approaches based on SD have little to do with the field of just transitions. Agnew, Smith & Dargusch (2018) and Blumberga, Timma & Blumberga (2015) focused on the adoption of balancing tools in local renewable systems; Capelo, Ferreira Dias & Pereira (2018), Castaneda, Franco & Dyner (2017) and Kubli & Ulli-Beer (2016) modelled the impacts of policies and technologies on energy activities; Liu et al. (2018), Selvakkumaran & Ahlgren (2018a), Matthew, Nuttall, Mestel & Dooley (2017) and Brouwer et al. (2018) analysed the effects of policy support or other social factors in the deployment of renewable technologies, endogenous electricity demand or resource efficiency; Hollmann & Voss (2005) modelled the decentralisation of energy supply; Pruyt & Thissen (2007) studied the European electricity sector from a local viewpoint; Pruyt (2011) opted for the smart transition management; and finally, Zhao et al. (2018) modelled the sub-national implications of carbon trading mechanisms.

In the frame of local scales, rural energy transitions have documented the power of sparsely populated areas to attract renewable facilities, notably wind farms (Rudolph & Kirkegaard, 2019), and the subsequent possibility to reinforce entrepreneurship (Morrison & Ramsey, 2019) and foster innovation (Dawley, 2014). Nonetheless, this body of literature has not documented so frequently the social contestation against said rural renewable facilities (Naumann & Rudolph, 2020; Phadke, 2011; Rudolph & Kirkegaard, 2019; Shamsuzzoha, Grant, & Clarke, 2012; Woods, 2003).

Papers about rural energy transitions have also eluded quantitative techniques, probably because of the scarcity of data at a small scale. However, the literature about local SD points to the suitability of this technique in contexts of data shortages, as it allows the integration of data directly from local stakeholders as primary sources of information (Selvakkumaran & Ahlgren, 2020). Simultaneously, the literature about rural areas demands greater systemic thinking and more precisions to ensure certainty (Naumann & Rudolph, 2020). Thus, rural studies claim for a tool that has a growing background in local studies, though at a greater scale.

It is therefore desirable in our novel contribution about the case of León to take advantage of the strengths of SD, like holistic thinking and the possibility to include data from stakeholders on the ground, to present an aprioristic analysis. Hence, we propose looking to the future while navigating the methodological difficulties of the rural scale, as explained below.

3.3.2. Modelling strategy and sources of information

Accounting for these challenges and limitations, SD inspires the design of a simple and affordable dynamic modelling exercise that captures the trade-offs of the Leonese transition and could well illustrate the situation of other fossil-dependent areas in developed contexts.

The phases to build this model are the following (Figure 3-7):

- Revision of current political plans. The first step is to revise the plans of intervention that have been developed by the Spanish Institute of Just Transition at the MITECO. This revision serves to determine the priority areas of intervention and the status of the process, delimitation, and analysis.
- Determination of the main socioeconomic dynamics and missing points. Based on the analysis, we determine the main fronts of the process of restructuring and detect the absent elements in the diagnosis made by the public organism in coherence with the theoretical framework of the just energy transitions and the results of the literature review.
- Translation of socioeconomic dynamics and missing points into a stock and flow rationale based on SD. Once the potential elements of the model have been detected, we translate them into a modelling language that enables subsequent empirical work. As the basis is SD, we have looked for variables that are suitable to picture the most immediate socioeconomic dynamics of the case, hence determining if they are stock, flow or auxiliary variables, and depict the relations among them. As a result, we generate the diagram of influences and the stock and flow diagram (Forrester) that allows simulation.
- Selection of data. As we are working at such a reduced scale, the selection of variables in previous stages has been done in coherence with data availability and capitalising on the advantages of SD to include stakeholders' information directly from the diagnosis of political plans. We combine energy, environmental and human data.
- Design of scenarios. The lack of certainty in political plans does not allow to derive scenarios that are immediately aligned with future actions. Consequently, scenarios in this modelling exercise are orientated to illustrate the conjunction of energy, environmental and social dynamics. The focus point is, therefore, how the key elements of the local transition interact, with a special interest in spatial dynamics.

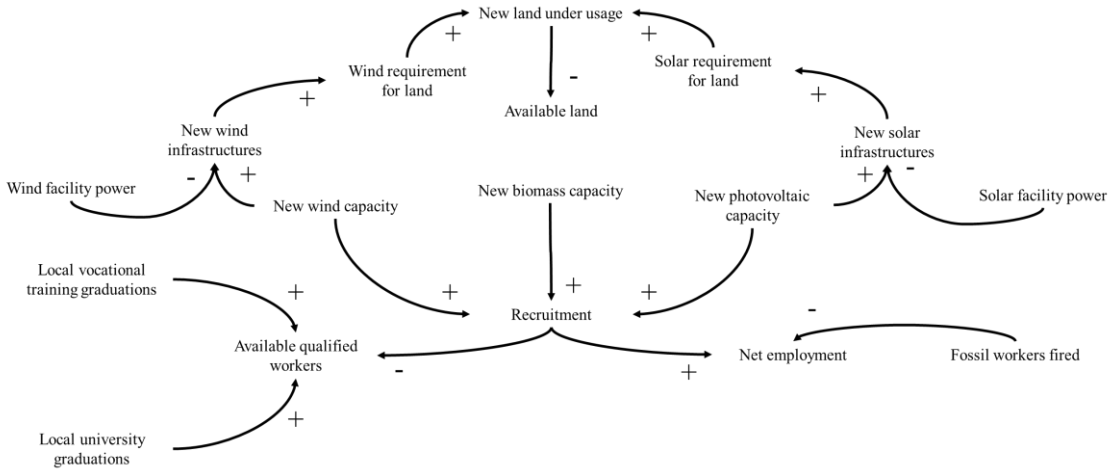
- Simulation. This final phase consists of the introduction of data into the stock and flow diagram and the execution of subsequent runs to obtain the results that motivate the discussion of the conclusions and policy implications of the case, which could be useful for stakeholders and political managers, in combination with the detected missing points.

Figure 3-7 Modelling process

Source: Own elaboration.

The selection of variables is based on three criteria: simplicity, relevance, and availability. Simplicity is mandatory provided that just transitions are public participatory processes that gather diverse social agents. Simple choices promote an intuitive and achievable mutual understanding, therefore incentivising transparency and vivid participation. Relevance secures a fit between analytical choices and the hotspots, as reported by local stakeholders through the CTJ. Last, but not least given the context under study, variables must be publicly available at a local level in rural areas, as well as in other possibly similar zones, to ensure replicability and methodological significance. The relations between the selected variables under these criteria are shown in Figure 3-8.

Figure 3-8 Diagram of influences of the Leonese case



Source: Own elaboration.

The model runs in subsequent stages, simultaneously in the two areas of just transition:

- First, we introduce the scenarios of new installed capacity in wind (W), solar photovoltaic (PV) and biomass (B) power, as they are the most relevant technologies for the transition as found in the literature review (Chapter 2) and the CTJs.
- Second, these new capacities are translated into required land (RL) by applying the standard commercial power of wind and photovoltaic infrastructures (p) and their associated use of land through the projection of elevations to the ground as observed in satellite images of local similar installations (r). Land requirements are the unitary demand for land of each turbine and panel so that they progressively reduce the stock of available land (AL).

$$RL_t = \frac{W_t}{p_w} r_w + \frac{PV_t}{p_{pv}} r_{pv}$$

$$AL_t = AL_0 - \sum_{1}^{t} RL_t$$

- Concurrently, capacities are translated through technology-specific employment factors (n) into direct labour demand (N), which increases the stock of net employment in energy activities (NN), also reduced by the destruction of jobs in risk in coal activities (NR) from a net employment perspective. Employment factors are the ratios between registered local workers in renewable energy activities and the installed renewable capacity on the basis of the direct impact (Cameron & Van Der Zwaan, 2015) and have been specially calculated for this case study to prevent misleading reuse of generalised or outdated factors in compliance with the precaution formulated in the niches of the literature review and research agenda (Section 2.5). The availability of qualified workers (AW) is cross-checked with the educated working-age population (P) and the new graduates in the local vocational training centres (GV) and Universities (GU) in key technical fields for a just transition.

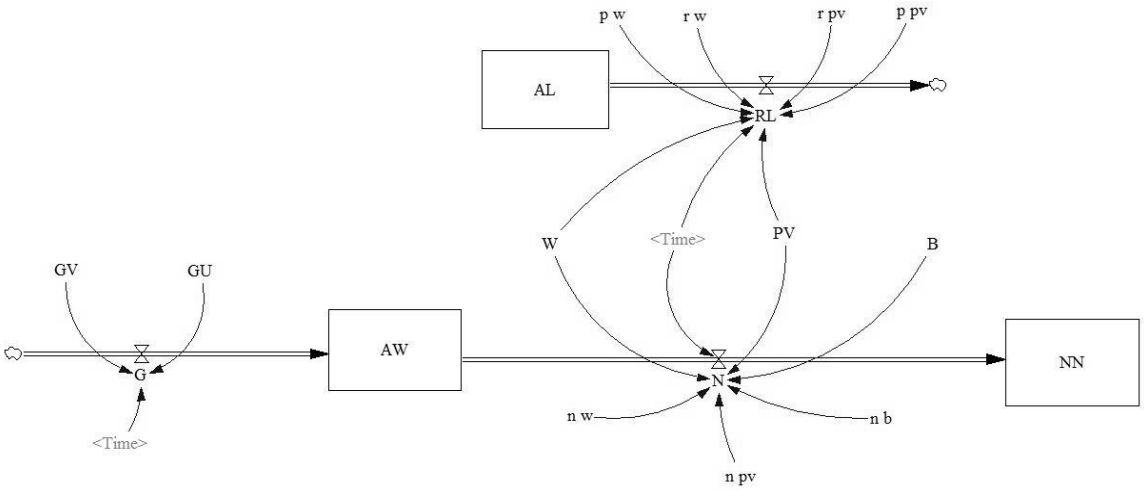
$$N_t = W_t\, n_w + PH_t\, n_{pv} + B_t\, n_b$$

$$NN_t = -NR_0 + \sum_{1}^{t} N_t$$

$$AW_t = P_0 + \sum_{1}^{t} GV_t + \sum_{1}^{t} GU_t - \sum_{1}^{t} N_t$$

The SD structure of the model following this rationale and notation is presented in Figure 3-9.

Figure 3-9 Forrester diagram of the Leonese case



Source: Own elaboration.

Selvakkumaran & Ahlgren (2020) came up with a classification of models about local transitions through SD that is based on six criteria: sectorial focus, type of transition, modelling depth, objective, justification for the use of SD and the level of interaction with the local scale. Following this classification, we can place this exercise in the state of the art. Our methodology presents a focus on energy, precisely on the mining and the electricity sector amid the energy transition, but also derives conclusions for agriculture and other non-energy sectors. Even if we provide systemic thinking arguments and a Causal Loop Diagram (CLD) (Figure 3-8), the core of the model is a Stocks and Flows Diagram (SFD) used for simulation (Figure 3-9). Our goal is both prescriptive and evaluative, as we are aimed at exploring solutions and providing a tool to assess potential projects. As stated in the Section of precedents, the reason to apply SD is the need to encompass energy, land and human variables in the same modelling framework, a motive that falls between systemic thinking and the necessity to bridge said issues. Finally, the level of interaction with the local scale is strict: we do not appeal to landscape factors beyond the local focus and integrate information from local stakeholders through the CTJ, both qualitative to determine the worries and relationships of the transition (Figure 3-8) and quantitative to obtain parameters for the simulation (Table 3-4).

Accordingly, the data to execute the simulation come from a variety of sources (Table 3-4).

Table 3-4 Data sources to feed the local model

Category	Variable	Sub element	Source	
			Reference	Public registry (R), local stakeholder (S) or user-defined (U)
Energy	New renewable capacity (W, PV, B)	Current tenders	Secondary source: ISTAS (Pérez Díaz & María-Tomé Gil, 2020). Primary source: local energy authorities.	S
		Territorial distribution	Scenarios	U
	Standard power of renewable infrastructure (p)	Wind turbines	Industrial standards	U
		Photovoltaic panels		
		Biomass	Own estimate based on current registers at a province level	
Land	Available land (AL)	Municipal surface	Council of León (Council of León, 2021)	R
		Urban land	Land registry (Spanish Land Registry, 2021)	R
		Woodland	Forest Inventory of the Castile and León Regional Council (Castile and León Regional Council, 2021)	R
	Land requirements (r)		Satellite estimates based on similar local facilities	U
Human	Qualified working-age population (AW)	New vocational training graduates	National Registry of Teaching Centres, Spanish Ministry of Education (Ministry of Education and Vocational Training, 2021)	R

			& Castile and León Regional Council (Castile and León Regional Council, 2020)	
		New University graduates	Statistics and Transparency Bureaus of the local Universities (National University of Distance Education, 2021; University of León, 2021)	R
		Educated working-age population	Agreements, Institute of Just Transition (Ministry of Ecological Transition and Demographic Challenge, 2020h, 2020i, 2020j, 2020k, 2020l)	R
	Employment factors of renewables (n)		Own estimate based on: Secondary source: ISTAS (Pérez Díaz & María-Tomé Gil, 2020). Primary source: Business registry (Registradores, 2020).	R
	Jobs at risk in fossil activities (NR)		Secondary source: Agreements, Institute of Just Transition (Ministry of Ecological Transition and Demographic Challenge, 2020h, 2020i, 2020j, 2020k, 2020l). Primary source: affected local companies.	S

Source: Own elaboration.

The simulation relies on parameters r, p and n to translate new energy capacity into new jobs and estimate the land requirements for renewable technologies. These parameters are grounded on data and assumptions.

Concerning employment factors (n), we take the ratio between the current number of employees in companies of renewable energy and the current capacity. This calculation is performed specifically for the Leonese case based on currently registered data, to prevent the inadequate reuse of employment factors detected in the literature review in Chapter 2. Based on current data, only the factors of solar PV, wind and biomass power can be estimated: jobs in hydropower are marginal and appear mixed up with other categories in the registries.

Regarding the land requirements of renewables (r), we focus on wind and solar power. Based on satellite images, we suppose that turbines with a diameter of 90 m will constitute wind power facilities with distances of 400 m between generators and solar facilities will rely on standard panels of 13x8 m with 20 m of distance. Under these dimensions, considering industrial standards, turbines would add (p) 2 MW and panels, 0.0184 MW.

3.4. Scenarios and results of the simulation

Once the CTJ have been critically analysed, we disclose the results obtained under our suggested quantitative framework.

We propose the simulation of four scenarios (Table 3-5). In the first scenario (SCEN 1), we install preferentially in the affected areas 50% of the current renewable tenders at a province level (769 MW of wind and 3,647 MW of solar PV) and maintain the current biomass potential. The second scenario (SCEN 2) calculates the effects of a more realistic situation in which 80% of wind tenders and 30% of PV tenders are placed in the affected areas due to their comparative advantage in wind speeds. As in SCEN 1, the biomass potential is constant. In the third scenario (SCEN 3), we replicate SCEN 2 with a year-on-year increase of 5% in the biomass potential. Finally, SCEN 4 replicates SCEN 3 under the employment factors that gradually converge with their average in the scholarly literature (Cameron & Van Der Zwaan, 2015; Fragkos & Paroussos, 2018; Ortega, del Río, Ruiz, & Thiel, 2015; Rosebud Lambert & Pereira Silva, 2012; Rutovitz, Dominish, & Downes, 2015). This average value is calculated by adding direct jobs in Construction, Installation, Manufacture, Operation and Maintenance (Table 3-6).

Table 3-5 Scenarios about the Leonese transition

Scenario	Proportion of current tenders installed in the affected areas		New annual biomass capacity	Employment factors
	Wind	Solar PV		
SCEN 1	50%	50%	0%	Current
SCEN 2	80%	30%	0%	Current
SCEN 3	80%	30%	5%	Current
SCEN 4	80%	30%	5%	Current (2021) to average in literature (2030)

Source: Own elaboration.

Table 3-6 Current employment factors of wind and photovoltaic power in León and estimates in the literature

Renewable technology	Employment factor (jobs/MW)	
	Currently in León	Average value in literature
Wind	3.563	7.092
Solar PV	2.447	18.857

Source: Own elaboration.

León registers employment factors notably below the average of the literature. However, such averages come from papers mostly focused on a national level. Given this discordance, we take these literature estimates in SCEN 4 ceteris paribus as a maximum or optimistic value to cover the range of the possible developments during the decade, so that the expected level of employment could be between the results of SCEN 1-3 and SCEN 4. Essentially, SCEN 1-3 is a set of BAU scenarios concerning employment factors.

Following the main worries of the just transition in León, we focus on the three stock variables of the model: available qualified workers (AW), net employment (NN) and land availability (AL) (Table 3-7).

Table 3-7 Results of the simulations of the Leonese case, SCEN 1-4

Variable (unit)	Area El Bierzo-Laciana					Area Montaña Central-La Robla				
	2021	2030				2021	2030			
		SCEN 1	SCEN 2	SCEN 3	SCEN 4		SCEN 1	SCEN 2	SCEN 3	SCEN 4
Available qualified workers (people)	7,365	11,270	11,700	11,670	7,640	1,175	2,717	3,151	3,135	-890
Net employment (people)	-714	1,911	1,477	1,511	5,536	-300	2,325	1,891	1,907	5,932
Land availability (Km^2)	1,552	1,422	1,458			742.9	613.1	648.7		

Source: Own elaboration.

The sole preferential installation of the current renewable energy tenders would have a positive outcome in the short term. The simulations converge to point out that the creation of direct jobs in renewables compensates the direct jobs at risk in fossil activities (net employment) in 2023 in El Bierzo-Laciana and 2022 in Montaña Central-La Robla. This outcome urges social agents to promote early programmes of reskilling and upskilling so that the affected workers can adhere to this creation of employment as soon as it happens.

Yet, even if renewables compensate for the negative impact of the phase-out of fossil facilities, they are unable to provide a significant proportion of occupation. The stock of available qualified workers is growing in SCEN 1-3, under BAU employment factors, as the new graduates in key disciplines increase at a higher pace than the recruitment in renewable sources. Solely under such optimistic values as the average literature factors in SCEN 4, recruitment would progress at a higher pace. Nevertheless, this optimistic assumption either absorbs new graduates in El Bierzo-Laciana and fails to recruit experienced workers or benefits experienced workers and neglects the novice, as the stock shows a similar level in 2021 and 2030. In Montaña Central-La Robla, it even leads to a shortage of qualified workers from 2029 onwards, as shows the negative level of the stock, which indicates the gap of workers to cover.

The average employment factor of wind power in literature is feasible: it implies doubling the jobs per installed MW along the decade. This event is likely as the areas are optimal for wind power infrastructures. Nonetheless, the average employment factor of solar PV is out of reach in absence of a very unlikely revolution in these particular areas, which are not the optimal ones in the region as they present below-average insolation and irradiance due to their geography and climate (Sancho Ávila et al., 2012). Hence, the most realistic outcome would be placed between SCEN 1-3 and SCEN 4, closer to the former, and more precisely, to SCEN 3, which nearly overlaps SCEN 2 due to the comparatively lower potential of biomass power to generate occupation.

Thus, the affected areas would experience a compensation of jobs at risk in the short term but fail to keep a qualified population in the medium term. Even in the optimistic SCEN 4, renewables will not provide the levels of employment that were registered in these areas, more than 45,000 miners, in the peak years of coal. Therefore, a partial just transition is highly possible, but it is too late for a complete just transition of the local energy sector. Alternatives like rural tourism, agroindustry and a “silver economy” with augmented social capacities and care (Díez Modino & Pardo Fanjul, 2020) are highly recommendable, although equally limited.

Regarding land requirements, the difference between equalising wind and PV and prioritising wind can be observed in the gap between SCEN 1 and SCEN 2-4. In El

Bierzo-Laciana, SCEN 2-4 involve a reduction of available land of approximately 6% in 2030, while SCEN 1 implicates a decline of 8.4%. Likewise, in Montaña Central-La Robla, SCEN 2-4 require a reduction of approximately 12.7% in 2030, while SCEN 1 results in a drop of 17.5%.

As the surface and the jobs at risk are higher in El Bierzo-Laciana, energy companies and competent authorities will probably choose to concentrate tenders in this area rather than distribute them equally between the two (as both present similar quality resources, as indicated in Section 3.2). Then, they will face a challenge to balance the creation of jobs without collapsing the available land in El Bierzo-Laciana while avoiding an alteration in the timings of the energy transition as well as unequal impacts between the two areas that could reinforce mistrust. To illustrate this sensitive balance that must be achieved, if the stakeholders decide to accomplish the likely SCEN 3 and carry 65% of tenders to El Bierzo-Laciana (SCEN uneq), it would cause a similar reduction in land availability in the areas (7.86% in El Bierzo-Laciana and 8.87% in Montaña Central-La Robla) and achieve net employment compensation approximately in the same period, but at the expense of losing 34.45% of net employment in 2030 compared to SCEN 3 in Montaña Central-La Robla (Table 3-8).

Table 3-8 Results of the simulation of the Leonese case, SCEN 3 under the unequal distribution of tenders to balance negative land impacts (SCEN uneq)

Variable (unit)	Area El Bierzo-Laciana			Area Montaña Central-La Robla		
	2021	2030		2021	2030	
		SCEN 3	SCEN uneq		SCEN 3	SCEN uneq
AW (people)	7,365	11,670	11,010	1,175	3,135	3,792
NN (people)	-714	1,511	2,168	-300	1,907	1,250
AL (Km^2)	1,552	1,458	1,430	742.9	648.7	677

Source: Own elaboration.

Increasing the proportion of PV tenders comes at a greater cost in terms of land: PV tenders are higher than wind tenders and the land requirement per installed MW of PV is approximately 46% higher than in the case of wind under the current simulation parameters. This outcome reinforces the strategic need to potentiate wind power in León, with more energy return and less demand for land. If wind tenders are prioritised, the interference of renewables and land for agriculture and livestock should be minimal given that wind facilities tend to be installed in higher fields, therefore less suitable for cultivation. The potentiation of wind power should consider the need for a local normative framework, as concluded by a study in the neighbouring area (Copena, Pérez-Neira, &

Simón, 2019). Future works could introduce in this modelling exercise Geographic Information Systems (GIS) or more specific Spatial Transition Analysis (STA), out of the scope of this thesis, to crosscheck the optimal location of renewable facilities, the current uses of land and local preferences (Oudes & Stremke, 2018), and ultimately forecast possible conflicts between energy and farming activities, particularly regarding communal woodlands.

3.5. Limitations of the processes and further corrections

Despite we tackle the quantitative dimension of the local rural scale, we cannot obviate a more qualitative dimension: that of the design and implementation of the processes of just transition that led us to this case. In the Spanish case, the CTJ.

The limitations detected below are the result of a review of the CTJ of León and a successive contrast with the framework of just transitions that we present in our theoretical framework and literature review (Section 1.4.2 and Chapter 2, respectively).

The limitations of the Leonese CTJ can be classified into three categories based on their nature: limitations concerning concept and design, diagnosis, and public participation processes, i.e., procedural weaknesses.

3.5.1. Concept and design

Given the contextualisation of just transitions based on the framework of the ILO and the scholarly literature, some limitations can already be observed:

First, processes focus exclusively on the quantification of jobs, the primary goal of the CTJ. Afterwards, the Institute has considered labour income too. Even if the quantification of jobs covers both own and outsourced workers, it is done at the moment of closure of the facility. Thus, CTJ consider the loss of 290 jobs in Fabero-Sil (282 after revision), 60 in Bierzo Alto (48), 62 in Laciana-Alto Sil (58), 302 in Cubillos del Sil-Ponferrada (279) and 300 in Montaña Central-La Robla (293), a total of 1,014 jobs (960 after revision). However, the diagnosis states that 5,156 jobs were destroyed between 1994 and 2009. Likewise, they document the presence of 45,212 mining workers in 1990 (Ministry of Ecological Transition and Demographic Challenge, 2020i, 2020j, 2020h, 2020l, 2020k). Consequently, it may be questioned if a criterium of impact at the closure of the facility, when the situation of decline is terminal, can be considered just in presence of historical destruction of jobs a couple of times higher.

The new criteria about the presence of miners in 2001 and 2011, introduced during the revision, have tried to solve this limitation (Ministry of Ecological Transition and Demographic Challenge, 2020e, 2020d, 2020a, 2020c, 2020b). Nevertheless, from the distributive and recognition viewpoint of the just transition, they are insufficient due to the avoidance of the historical quantification of the affected jobs.

The affected jobs have been quantified in direct terms (over mining and thermoelectric production), but indirect and induced impacts have not been determined, although they can be supposed high given the socio-economic situation (Table 3-1). Moreover, this impact is measured over the working-age population instead of the workforce due to a "lack of data at a municipal scale" (Ministry of Ecological Transition and Demographic Challenge, 2020i, 2020j, 2020e, 2020d, 2020a, 2020h, 2020l, 2020c, 2020b, 2020k). Groups of the inactive working-age population, like the called "discouraged workers", can cause situations that are not adjusted to real impact.

The focus on the creation of jobs omits the considerations highlighted by the ILO about its quality (Poschen, 2017). The creation of precarious employment as a result of the transition is a negative impact. Yet, there are no clear lines to ensure the quality of new or reconverted jobs beyond the spontaneous courses that arise in the Tripartite Dialogue.

In contrast with the consideration of the quality of jobs, there is an explicit and sound mention of gender equality goals, to which MITECO concedes an essential role in the transition (Ministry of Ecological Transition and Demographic Challenge, 2020f). Hence, it establishes ways of cooperation between the Institute of Just Transition and the Women Institute to execute consultive actions with local women associations to create equalitarian projects. At the same time, it acknowledges that the activities affected by the transition are widely linked with the male population. Therefore, justice implies that the net impact of these projects must be extensively positive under this interpretation. A compensation between destroyed and new jobs is not enough, even in case of variation of sociodemographic profiles, like the increase of women in technical professions. Not only must those projects cover the affected workers, but also assure new possibilities for the excluded female workers, in the words of the Institute. Again, given this goal, it may be questioned the justice of a calculation based on the affected jobs at the closure of the facility. At this moment, there is not any concretion in the CTJ about the precise contribution of women associations in León.

Additionally, based on the developments of the ILO (ILO, 2015; Poschen, 2017), not only jobs should be considered as a part of the just transition, but also the environmental deterioration that the CTJ confirm as a result of the abandonment of facilities, which, like employment and income, has asymmetric consequences with distributive implications. These impacts have been relegated in the diagnosis, even if they are recurrently cited as a problem and possible source of opportunities derived from their restoration. Diagnosis is in consequence of strict socioeconomic nature, and thus, it omits environmental justice, despite its potential to ease (e.g., by minimising the environmental impact to favour tourism or potentiate the biodiversity areas) or hinder the reconversion.

Similarly, the design of the CTJ motivates the consideration of other limitations derived from the remaining criteria.

The criterium of coverage to 85% of the affected workers implies the introduction in the CTJ of those municipalities that suffer an impact on their working-age population (or labour income after the revision) below the average until the consecution, but also the exclusion of municipalities with similar impacts to those that have been included (Table 3-9). The application of the criterium has been clear in the case of Montaña Central-La Robla because the inclusion of Villamanín municipality has left the cumulative percentage of affected workers exactly at 85%. On the contrary, the criterium has been problematic in the case of El Bierzo-Laciana, where it would have stopped the process of inclusion in Ponferrada (90.94% of workers covered), a town that should have been excluded for having a population greater than 70,000 inhabitants and being diversified. Its inclusion goes against the criteria of the MITECO and is justified because the town is "the leading and extensive sub-regional urban area and registers a high number of affected workers", according to the already-cited CTJ. This calculation would have left out of coverage Palacios del Sil, despite showing an impact of 0.0561 points below Ponferrada and being a non-diversified rural area. Nonetheless, Palacios del Sil has been included without an explicit explanation of this issue. We can intuit that its inclusion has tried to solve the error that would have implied the exclusion of the municipality, which reflects the inoperative nature of barrier criteria.

Table 3-9 Initial application of the criterium of coverage in the inclusion of municipalities by impact

CTJ El Bierzo-Laciana				
Municipality	Jobs	W. A. Pop.	Impact	Cum. Aff. W.
Cabrillanes	12	476	2.5210%	1.81%
Páramo del Sil	20	796	2.5126%	4.83%
Fabero	41	2953	1.3884%	11.03%
Villablino	70	5825	1.2017%	21.60%
Cubillos del Sil	14	1187	1.1794%	23.72%
Toreno	23	1992	1.1546%	27.19%
Bembibre	52	5739	0.9061%	35.05%
Ponferrada	370	41667	0.8880%	90.94%
Palacios del Sil	5	601	0.8319%	91.69%
TOTAL	607	61236		

CTJ Montaña Central-La Robla				
Municipality	Jobs	W. A. Pop.	Impact	Cum. Aff. W.
La Pola de Gordón	86	1901	4.5239%	47.78%
La Robla	50	2502	1.9984%	27.78%
Matallana de Torío	9	838	1.0740%	80.56%
Los Barrios de Luna	2	192	1.0417%	81.67%
Villamanín	6	585	1.0256%	85.00%
Carrocera	2	274	0.7299%	86.11%
TOTAL	155	6292		

Source: Own elaboration based on the CTJ.

In the CTJ, affected municipalities are also excluded when they do not belong to the autonomous community of reference to "respect the territorial scope", despite the processes and the Institute being national institutions. This issue is especially delicate in the case of León, where the affected areas are adjacent to Galicia and Asturias: if a Galician or Asturian municipality had resulted significantly affected by the closures in León, they would have been ineligible for their inclusion in the CTJ despite having similar socioeconomic situation.

For its part, the criterium of territorial coherence has procured coverage to municipalities with a lower impact than those included, e.g., Folgoso de la Ribera has been included with a 0.3% score while Priaranza del Bierzo has been excluded with a 0.66% score. This problem has been solved narrowly through the criterium of territorial cohesion. Given that, at the end of the process, the population of the selected municipalities represents 70.42% of the population of the sub-region, El Bierzo has entered as a whole in the coverage of the CTJ. In absence of such a modest margin, the described contradictions would have persisted. As happened with the criteria of barrier, it may be questioned the operativity of this criterium of territorial cohesion in circumstances close to the 70% limit.

3.5.2. Diagnosis

In the case of the diagnosis, the main limitations derive from the selection of indicators and the SWOT analysis.

Regarding indicators, there is a need to highlight the limitations of sociodemographic and income variables. Sociodemographic variables, notably those related to the level of education, have been gathered in the census in 2011 as the sole available source. Hence, they register a lag of more than 10 years, a decade that has resulted decisive in the decline of the mining and thermoelectric generation, and also reflects the impact of COVID. Contrary to this limitation, to design the model, we recur to data provided by current public registries, like the regional education authorities. Likewise, CTJ take the average labour income of the municipalities despite such income being only calculated for those municipalities of higher size or relevance, therefore biasing the diagnosis, and subsequently, the delimitation through this new criterium. These incomes are presented in current monetary units; hence, their variations could hide a "monetary illusion" in relatively wide and fluctuant periods as the ones analysed in the CTJ.

The limitations of diagnosis through these indicators motivate a reflection on the need for a data strategy before the strategy of transition, in which availability and quality of statistical information are tested and improved.

Regarding the SWOT analyses, there is a lack of specificity in the analyses, which have been reused in the previous process of diagnosis at an autonomous community level, and redundancy of statements.

The most affected areas necessarily present common traits due to their shared problems and the same socioeconomic context, so some degree of coincidence in diagnosis is expected. In the case of León, we have detected significantly high rates of coincidence, hence suggesting a lack of specificity in diagnosis or an unnecessary

disaggregation of the SWOT analysis in the priority areas. This limitation can be observed in Table 3-10.

Table 3-10 Percentage of coincidence among the statements of the SWOT diagnosis by CTJ, initial (Panel A) and after the revision (Panel B)

A

Strengths		CTJ Bierzo-Laciana				CTJ Montaña Central-La Robla
		Fabero-Sil	Bierzo Alto	Laciana-Alto Sil	Cubillos-Ponferrada	
CTJ Bierzo-Laciana	Fabero-Sil	-	22%	22%	22%	11%
	Bierzo Alto	22%	-	26%	33%	15%
	Laciana-Alto Sil	22%	26%	-	30%	19%
	Cubillos-Ponferrada	22%	33%	30%	-	11%
CTJ Montaña Central-La Robla		11%	15%	19%	11%	-

Weaknesses		CTJ Bierzo-Laciana				CTJ Montaña Central-La Robla
		Fabero-Sil	Bierzo Alto	Laciana-Alto Sil	Cubillos-Ponferrada	
CTJ Bierzo-Laciana	Fabero-Sil	-	56%	52%	40%	36%
	Bierzo Alto	56%	-	68%	52%	52%
	Laciana-Alto Sil	52%	68%	-	48%	52%
	Cubillos-Ponferrada	40%	52%	48%	-	40%
CTJ Montaña Central-La Robla		36%	52%	52%	40%	-

Opportunities		CTJ Bierzo-Laciana				CTJ Montaña Central-La Robla
		Fabero-Sil	Bierzo Alto	Laciana-Alto Sil	Cubillos-Ponferrada	
CTJ Bierzo-Laciana	Fabero-Sil	-	23%	23%	23%	27%
	Bierzo Alto	23%	-	27%	23%	27%
	Laciana-Alto Sil	23%	27%	-	23%	27%
	Cubillos-Ponferrada	23%	23%	23%	-	27%
CTJ Montaña Central-La Robla		27%	27%	27%	27%	-

Threats		CTJ Bierzo-Laciana				CTJ Montaña Central-La Robla
		Fabero-Sil	Bierzo Alto	Laciana-Alto Sil	Cubillos-Ponferrada	
CTJ Bierzo-Laciana	Fabero-Sil	-	46%	46%	31%	31%
	Bierzo Alto	46%	-	54%	31%	31%
	Laciana-Alto Sil	46%	54%	-	31%	31%
	Cubillos-Ponferrada	31%	31%	31%	-	23%
CTJ Montaña Central-La Robla		31%	31%	31%	23%	-

B

Strengths		CTJ El Bierzo-Laciana				CTJ Montaña Central-La Robla
		Fabero-Sil	Bierzo Alto	Laciana-Alto Sil	Cubillos-Ponferrada	
CTJ El Bierzo-Laciana	Fabero-Sil	-	22%	19%	16%	13%
	Bierzo Alto	22%	-	19%	25%	13%
	Laciana-Alto Sil	19%	19%	-	16%	13%
	Cubillos-Ponferrada	16%	25%	16%	-	16%
CTJ Montaña Central-La Robla		13%	13%	13%	16%	-

Weaknesses		CTJ El Bierzo-Laciana				CTJ Montaña Central-La Robla
		Fabero-Sil	Bierzo Alto	Laciana-Alto Sil	Cubillos-Ponferrada	
CTJ El Bierzo-Laciana	Fabero-Sil	-	36%	31%	33%	25%
	Bierzo Alto	36%	-	42%	33%	42%
	Laciana-Alto Sil	31%	42%	-	31%	36%
	Cubillos-Ponferrada	33%	33%	31%	-	28%
CTJ Montaña Central-La Robla		25%	42%	36%	28%	-

Opportunities		CTJ El Bierzo-Laciana				CTJ Montaña Central-La Robla
		Fabero-Sil	Bierzo Alto	Laciana-Alto Sil	Cubillos-Ponferrada	
CTJ El Bierzo-Laciana	Fabero-Sil	-	14%	10%	17%	21%
	Bierzo Alto	14%	-	14%	17%	17%
	Laciana-Alto Sil	10%	14%	-	10%	10%
	Cubillos-Ponferrada	17%	17%	10%	-	24%
CTJ Montaña Central-La Robla		21%	17%	10%	24%	-

Threats		CTJ El Bierzo-Laciana				CTJ Montaña Central-La Robla
		Fabero-Sil	Bierzo Alto	Laciana-Alto Sil	Cubillos-Ponferrada	
CTJ El Bierzo-Laciana	Fabero-Sil	-	26%	32%	16%	21%
	Bierzo Alto	26%	-	32%	21%	21%
	Laciana-Alto Sil	32%	32%	-	16%	21%
	Cubillos-Ponferrada	16%	21%	16%	-	26%
CTJ Montaña Central-La Robla		21%	21%	21%	26%	-

Source: Own elaboration based on the CTJ.

Initially (Table 3-10 A), the highest percentages of coincidence appear in the determination of weaknesses (Ministry of Ecological Transition and Demographic Challenge, 2020i, 2020j, 2020h, 2020l, 2020k). CTJ share more than 30% of the statements. Bierzo Alto and Laciana-Alto Sil show a 68% coincidence; Fabero-Sil and Laciana-Alto Sil, Bierzo Alto and Cubillos del Sil-Ponferrada, and Montaña Central-La Robla, Bierzo Alto and Laciana-Alto Sil record a 52% coincidence.

CTJ in Bierzo Alto and Laciana-Alto Sil again show the highest coincidence scores in the section of threats (54%) and opportunities (27%), as well as a high percentage, although in a medium range, regarding strengths (26%).

Cubillos del Sil-Ponferrada and Bierzo Alto have the most elevated concordance score concerning strengths (33%). The delimitation of opportunities presents a lower coincidence and range than the rest of the sections.

In the phase of revision (Table 3-10 B), the coincidences are attenuated (Ministry of Ecological Transition and Demographic Challenge, 2020e, 2020d, 2020a, 2020c, 2020b). Indeed, additional elements have been introduced in the SWOT analyses with a slight increase of specificity: for instance, there is a citation to the ski resort in Leitariegos in the CTJ Laciana-Alto Sil, the PCI in Cúa in Fabero-Sil (even if the PCI of Bierzo Alto has been omitted), inter alia.

In addition to this coincidence, redundancy is abundant in the Leonese SWOT analyses. These redundancies consist of the repetition of a statement by analytical category with an identical implication, but a different expression, and thus, they do not provide additional valuable information and disperse the conclusions of the diagnosis. As far as the weaknesses are concerned, we can observe the concurrence of “Absence of alternatives to mining”, “Specialisation in mining”, and “Lack of diversification”, which essentially share the same meaning. We can also find “Unemployment” and “Imbalance between labour supply and demand” or “Self-supply smallholding agriculture” and “Smallholding agricultural sector”. Among the threats, there are “Proximity of dynamic nucleus of population” and “Emigration towards urban areas” or “Absence of innovative activity” and “Loss of innovative activity”. Regarding strengths, the redundant statements are “Industrial and mining patrimony” and “Historical and cultural patrimony” together with “Patrimonial richness”; “Tourism and leisure potential” and “Potential resources for tourism”; and “Renowned agri-food products” with “Prestigious production of meat”. Finally, among opportunities, we can find “Potentiation of hydro resources, hunting and fishing” with “Exploitation of the own resources” (which should not be considered as a proper opportunity given that it is the primary goal of the CTJ, as happens with “Potentiation of alternative activities to mining” or “Reorientation towards renewable energy sources”); “Existence of a market for quality products and agricultural

professionalisation" with "Traditional products"; and "Institutional support for an alternative development and IT" with "Support from the regional Council for education". This way, percentages of redundancy in the SWOT have been calculated per CTJ (Table 3-11).

Table 3-11 Percentage of redundancy of SWOT statements, initial (Panel A) and after the revision (Panel B)

A

Redundancy	CTJ El Bierzo-Laciana				CTJ Montaña Central-La Robla
	Fabero-Sil	Bierzo Alto	Laciana-Alto Sil	Cubillos-Ponferrada	
Strengths	27%	18%	20%	25%	0%
Weaknesses	37%	26%	28%	14%	15%
Opportunities	0%	0%	0%	27%	20%
Threats	29%	29%	29%	22%	0%

B

Redundancy	CTJ El Bierzo-Laciana				CTJ Montaña Central-La Robla
	Fabero-Sil	Bierzo Alto	Laciana-Alto Sil	Cubillos-Ponferrada	
Strengths	42%	36%	22%	21%	0%
Weaknesses	45%	18%	12%	12%	13%
Opportunities	0%	29%	0%	24%	18%
Threats	22%	0%	25%	18%	0%

Source: Own elaboration based on the CTJ.

The CTJ of Fabero-Sil presents the highest redundancies, both initially (Table 3-11 A) (Ministry of Ecological Transition and Demographic Challenge, 2020j) and after the revision (Table 3-11 B) (Ministry of Ecological Transition and Demographic Challenge, 2020c).

Surprisingly, after the revision redundancy has increased: 45% of weaknesses, 22% of threats and 42% of strengths are repetitive statements. The same applies to strengths (from 18% to 36%) and opportunities (from 0% to 29%) in Bierzo Alto (Ministry of Ecological Transition and Demographic Challenge, 2020a, 2020h) and the strengths in Laciana-Alto Sil (from 20% to 22%) (Ministry of Ecological Transition and Demographic Challenge, 2020d, 2020k). In the comparative, we can detect an attempt to reduce these redundancies, as proves the remaining quadrants, but this attempt has been frustrated with the inclusion of new specific elements: for example, in Fabero-Sil, the "Lack of quality in road and communication infrastructures" has been included simultaneously with "Insufficiency of telecommunication services"; or the "Presence of biosphere reserves" when a similar statement "Biosphere reserves and biodiversity" was already present. With the phase of revision, there are new redundancies, not only regarding SWOT categories but also among them: for instance, the existence of bad communications as a weakness and a threat or the ski resort in Leitariegos as a strength and an opportunity.

Both phenomena, coincidence and redundancy, configure diagnoses that are more limited and dispersed than expected in the case of a proposal for a just transition with a high specificity between areas.

Beyond these limitations, it is worthy of note the consideration of some elements in the diagnosis and their unjustified changes during the phase of revision. In the CTJ in Bierzo Alto, it is considered a weakness the presence of "High levels of income and the sale of properties" (Ministry of Ecological Transition and Demographic Challenge, 2020a). Similarly, there is an explicit mention of the unfavourable situation of workers in connection with the goals of gender equality, but this mention has not been included in all the CTJ, just in Bierzo Alto (Ministry of Ecological Transition and Demographic Challenge, 2020a) and Montaña Central-La Robla (Ministry of Ecological Transition and Demographic Challenge, 2020e). Regarding unjustified changes, the CTJ in Laciana-Alto Sil is a notable case: initially, it had a "business sector compromised with the territory" (Ministry of Ecological Transition and Demographic Challenge, 2020k), but after the revision, it has a "business sector not compromised with the territory" (Ministry of Ecological Transition and Demographic Challenge, 2020d) without an explicit argumentation at this regard.

These issues point to a dysfunctional application of the SWOT analysis, considering the end that is presented in the CTJ. Consequently, it is highly recommendable that the Institute and the stakeholders explore alternative techniques of diagnosis and correct this lack of specificity and the dispersion that the Leonese CTJ show.

3.5.3. Processes of public participation

From a procedural viewpoint, channelled in the CTJ through questionnaires and technical meetings (Ministry of Ecological Transition and Demographic Challenge, 2020e, 2020d, 2020a, 2020c, 2020b), apart from the mentioned doubts about gender equality that have been previously disclosed due to their conceptual nature, diagnoses have not included the worries of the growing movements of opposition to the installation of renewables in the affected areas. The opposition in León is based on three main conflicts: the displacement of farmers, the management of the communal woodlands and the environmental-landscape impacts of the installations.

In the affected areas and many other locations in the province and the community, the installation of renewable infrastructures is motivating a change in land uses. Currently, many smallholdings that are suitable for the renewable generation of electricity are abandoned or rented to farmers. The massive and profitable deployment of renewable technologies during the transition has led energy corporations to offer greater renting proposals than those agreed with the lessee farmers. The highest profitability of renting for renewables in comparison with the primary renting involves the expulsion of farmers, incapable of equalising or improving the corporate offers. Those affected see their sustenance at risk while, in the best of situations, they are offered non-satisfactory jobs in the new renewable installations.

Simultaneously, there are frictions between the demand for land and the management of the traditional woodlands. Even if the impacts on these collectively managed woodlands have serious implications regarding justice and affect rural agroecological development, their precise case has not been addressed in a specific way in the processes of transition. This omission can be related to two issues: one connected with the design, already mentioned, and the other distinctly procedural. At first, CTJ are of an eminently social and economic nature, and relegate the environmental impacts, including land uses, despite their implicit socioeconomic character. Secondly, from a procedural point of view, the model of communal management is sufficiently specific at a local scale to be overlooked in absence of inclusive participatory processes. Again, this analysis reveals a lack of specificity linked with a possible omission of relevant stakeholders.

Aligned with the changes in land uses, the environmental-landscape issue is linked to the need of releasing the territory from biodiverse uses or uses with an aesthetic value to enable the installation of generating technologies. Strategies to tackle this matter remain to be specified in the CTJ.

In brief, the procedural problem of the Leonese CTJ is rooted in the implicit socioeconomic and environmental effects of changes in land use, not so much in labour issues, widely covered, despite the indicated limitations.

After presenting the insights provided by modelling and further suggestions to correct the processes, in the following Chapter, we dive into welfare regimes and policies, and their potential for eco-social synergy to ease the restructuring.

3.6. Conclusions and policy implications

In the field of just energy transitions, national scales, and more recently regional scales, lead the available literature. Conversely, local cases have maintained a secondary position, frequently limited to qualitative methods aligned with socio-technical theories far from the proper framework of just transitions, under a posteriori techniques and without the needed specificity and the inclusion of complex dynamics. Regarding quantitative methods, local cases are paying increasing attention to System Dynamics because of its holistic ability, the possibility to increase specificity and integrate data from stakeholders to alleviate data shortages at such a small scale.

Regarding local contexts, research about rural energy transitions tends to elude quantitative techniques, probably because of the scarcity of data at a small scale, while demanding greater systemic thinking and more precisions to ensure certainty. Thus, rural studies claim for a tool that has a growing background in local studies, though at a greater scale. We gather these insights and claims to contribute to the quantitative study of proper just energy transitions with the case of restructuring of the rural mining areas of León

(Spain) towards renewable energy sources through an intuitive, scalable and easily adaptable modelling exercise based on System Dynamics.

These areas have suffered deep negative impacts because of the decline of coal extraction and thermoelectric production during the past three decades, such as unemployment, local migrations, depopulation, ageing and increasing dependence, as well as environmental impacts. The need for a just transition in León gains momentum and congregates growing institutional support under the Institute of Just Transition. Yet, stronger opposition movements complain about the social and ecological impact of these technologies, which are threatening to displace lessee farmers from their cultivations and hinder new uses for tourism or agroindustry.

This Chapter models the two fronts of the just transition in León, net employment and land requirements, through SD to combine local energy, land and human systems, given the suitability of this methodology. The model is designed under the premises of simplicity, to promote equal social participation, relevance, to face the hotspots of the transition, and restricted availability of information, to cover local studies in rural contexts with data scarcity. Such scarcity is extreme in the Leonese case as we are working at a strictly local scale through the aggregation of mining municipalities differentiated into two areas. Previous local approaches with SD did not face such a challenge, as they adopted a wide conception of the local scale, mainly with a regional and not necessarily rural focus. With the resultant tool, we simulate four incremental scenarios based on ceteris paribus observation. These scenarios account for the potentiation of wind power tenders due to the comparative advantage of the affected areas in wind generation, the impact of the potentiation of cumulative biomass capacity and the convergence of below-average techno-specific employment factors to the mean factors of scholarly literature.

We conclude that the current tenders have the potential to compensate the jobs at risk by 2022-2023 so social agents should immediately implement upskilling and reskilling programmes to ease the process and benefit workers in the short term. In the most optimistic scenario, the transition is unable to absorb the flows of newly qualified workers in the most dynamic area of El Bierzo-Laciana and causes a shortage of workers in the less dynamic Montaña Central-La Robla. More realistic scenarios project the incapacity of renewables to keep a young, qualified population in the areas. Alternatives like rural tourism, agroindustry and a “silver economy” with augmented social capacities and care are highly recommendable but equally limited.

Besides, the increase of local wind tenders is the most adequate option to maximise renewability and generate employment while minimising conflicts related to land uses. Even if the model detects a significant decrease in land availability by 2030,

there are not any reasons to interfere with farming zones if the tenders follow the wind potentiation strategy. However, the areas will face sensitive trade-offs between negative impacts on land use and positive impacts on employment. If such trade-offs are mismanaged, they could result in comparatively unfair outcomes in the areas and reinforce public mistrust. Future works should apply GIS and STA to crosscheck the optimal locations of renewable infrastructures and land uses, considering local preferences and conflicts.

Based on these findings, the just transition of the Leonese energy sector will be partially just with the mere strategical management of the current renewable tenders and the implementation of upskilling and reskilling programmes. However, a proper and full just transition is three decades late. The mining areas will not meet again the brilliant times of the 1980s but will probably inspire modest developments in a more sustainable near future.

These results and the proposed methodology point to some policy implications that apply to other rural mining areas in developed countries and under intense deindustrialisation during the last decades. Also, these implications appeal to a reform of the qualitative dimension of the CTJ, analysed in Section 3.5.

First, just energy transition plans usually have a narrow focus on net direct employment in the energy sector. As shown, a just energy transition requires a cross-sectorial approach because the phase-out of mining and thermoelectric production has indirect and induced effects on the local economies (Table 3-1) and renewable technologies are unable to provide significant shares of employment in such reduced scales (Table 3-7).

Parallelly, just energy transition plans tend to deal strictly with the socioeconomic effects of restructuring and neglect the environmental effects, despite their implicit socioeconomic consequences. The environmental impacts of new jobs, their quality, and their implications for land use, together with the landscape effects of the phase-out of coal, are perceived as a separate dimension, even if stakeholders appreciate the potentiality for biodiversity and rural tourism, as happens in León. It is impossible to isolate environmental impacts from socioeconomic effects: human and land dynamics constitute the system of the just energy transition (Figures 3-8 and 3-9) and have simultaneous reactions with implications for justice and social contestation (Table 3-7).

The inspection of environmental effects, and particularly land dynamics, is of uttermost relevance to promote justice and tackle social contestation in near areas that undergo the process of transition simultaneously under similar socioeconomic situations, like El Bierzo-Laciana and Montaña Central-La Robla. Potential asymmetries (Table 3-8) will immediately erode social trust and must be an element of further reflection in

connection with the procedural dimension of the just transition in political plans. The technological improvement of renewable technologies and the compatibility of land uses should be carefully taken into consideration in this regard.

Second, just transition plans should pay greater attention to the role of education, especially in these rural areas. Education is responsible for the flows of available qualified workers (Figure 3-9) and the mitigating effects of upskilling and reskilling programmes. Its role stands out in the extremely local labour markets of rural places, involved in deep processes of depopulation, as happens in Spain and León, where there is a strong will to retain and incentivise a young and qualified population. Local education centres go hand in hand with justice: vocational training, university studies and lifelong learning in energy and non-energy activities (social and cultural services for the community, human resources, geography and landscape planning, construction and civil infrastructure works, inter alia) should be promoted in combination with the required upskilling and reskilling programmes for the most affected sociodemographic profiles.

Third, public authorities and other stakeholders should prepare to evaluate if a partially just energy transition is satisfactory to fulfil their claim for justice in such afflicted areas. The decline of coal began by the end of the 20th century, as happened in the Leonese areas, but the framework to promote a just transition was especially motivated by the SDGs from 2015. Political plans are therefore applied after some decades of socioeconomic deterioration that can be irreversible, as in this case (Tables 3-1 and 3-7). This partial outcome persists despite the introduction of additional criteria in political plans to account for the time gap, considered in the Spanish CTJ (Section 3.1), and threats to further erode social trust.

Finally, diving into these conclusions is not complicated under the methodology proposed. The data that feed this simple model have been gathered by public authorities together with other stakeholders (Table 3-4), who, notwithstanding, have eluded precise connections between them and the subsequent estimation of their implication for justice, as we have done. The methodological limitations of local, and specifically rural scales should not impede deploying quantitative modelling techniques to guide policies. A simple analysis of how local systems evolve, linked with the difficulties on the ground as proposed here, provides valuable political information and enables the consideration of decentralised political solutions, in contrast with the centralised perspective of many political strategies of the energy transition, formulated in aggregated terms for greater scales that are not facing primarily the precise challenges of these areas.

Chapter 4

WELFARE REGIMES AS ENABLERS OF JUST ENERGY TRANSITIONS: REVISITING AND TESTING THE HYPOTHESIS OF SYNERGY FOR EUROPE

In the just transitions debate, as we have just seen in the Leonese case, societies are always facing a trade-off between social and environmental goals. It is in this debate that the WS is doomed to play a prominent role. In effect, as a key means to compensate for negative impacts and potentiate positive outcomes, it might contribute to enhancing just energy transitions. It is no accident that in the last years there has emerged important literature on these potentialities, but also on the implications they have for the analysis and prospects of WS.

WS, as theorised in our theoretical framework (Section 1.4.3), are those that at least assume the direct provision of social services, like social security, health, education and housing, regulate private activities to shape the economy and provide cash benefits (Corlet Walker et al., 2021; Gough, 1979).

In this regard, one issue arises with great relevance: the "hypothesis of synergy". It states that Social-democratic WS in the sense of Esping-Andersen (Esping-Andersen, 1990), i.e., those with high decommodification and low social stratification, are in a better position to perform the transition to Environmental States (ES), therefore establishing an eco-social synergy. Social-democratic WS are identifiable under Esping-Andersen's classification for facilitating a good life to their citizens regardless of their level of market implication and presenting lower differences between the income levels of the most favoured and the least favoured individuals.

The ES, also called Eco States, Green States or Ecological States (Bäckstrand & Kronsell, 2015) are those that rely on a significant institutional configuration to manage the environment and its interactions with society so that the social-environmental conjunction is a continuous focus of political activity (Duit et al., 2016) to achieve a sustainable future domestically and globally (Bomberg, 2015). This "significant" institutional configuration involves specific environmental ministries and agencies, environmental legislation and its adjoining regulatory organisms and mechanisms, environmental taxation and dedicated budgets, as well as advisory scientific organisations to orientate actions (Duit et al., 2016; Jakobsson et al., 2018).

Whereas the hypothesis has been remarkably worked theoretically (Dryzek, 2008; Gough, 2016; Gough et al., 2008; Meadowcroft, 2008), its empirical verification remains less studied, even in such fields as Comparative Political Economy (Wood et al., 2020). To our knowledge, only five studies (Fritz & Koch, 2019; Jakobsson et al., 2018; Koch & Fritz, 2014; Otto & Gugushvili, 2020; Zimmermann & Graziano, 2020) have tried to verify it and reached complex contradicting results that deserve more analytical efforts and a deeper reflection.

This Chapter shows our attempt to revisit the hypothesis of synergy considering the limitations of previous studies and "explore the capability of welfare regimes to ease the transition and provide a sustainable and just future", coherently with the third secondary goal of this thesis. Besides, it fully addresses the second research hypothesis, corresponding to the proper hypothesis of eco-social synergy. The following Section presents a theoretical-empirical alignment of the topic. Afterwards, we propose a set of solutions to the limitations of empirical indicators and include missing variables after such an alignment. Subsequently, in Section 4.3, we detail the data sources and the procedures that these data have undergone to derive the interpretation of the results in Section 4.4. Finally, Section 4.5 discusses the implications of the results and dives into the tools of SW to enable synergy, with a particular interest in local rural areas.

4.1. Theoretical-empirical alignment

Social and environmental policies can be conflicting (Dryzek, 2008; Koch & Fritz, 2014). First, WS rely on public revenues, which depend either on a politically challenging redistribution or on economic growth. Growth has been widely considered unsustainable, so that welfare policies could be harming the environment despite their social potential (Bailey, 2015; Borgnäs et al., 2015; Büchs & Koch, 2017; Hirvilammi, 2020; Weiss & Cattaneo, 2017). Second, environmental measures tend to be regressive and represent proportionally a heavier burden for less favoured individuals than for the most favoured ones (Arndt, Miller, Tarp, Zinaman, & Arent, 2017; Fischer et al., 2016; Frondel et al., 2015). Third, income distribution propitiated by WS may increase environmentally harmful emissions through the consequent stimulus of a potentially unsustainable consumption derived from increases in disposable income (Gough, 2017). Fourth, considering limited public budgetary capacities, social and environmental measures compete for fiscal funding (Dryzek, 2008; Jakobsson et al., 2018). Fifth, WS and ES differ in their scope: while WS redistribute income and face individually unpredictable but collectively predictable risks, ES redistribute environmental costs and benefits and face collectively unpredictable risks (Dryzek, 2008; Duit et al., 2016).

In contrast, synergy implies that WS serve as a precondition to implementing ES, and sustainability and well-being are interconnected (Ivankina & Latygovskaya, 2015). Special attention has been given to the Nordic countries as accurate representatives of

Social-democratic WS (Esping-Andersen, 1990), with apparently positive environmental and energy situations (Kemfert, 2017; World Energy Council, 2020) and supportive public attitudes (Otto & Gugushvili, 2020). According to the hypothesis, the drivers of synergy are:

- High decommodification, i.e., the strong likelihood of reaching a satisfactory standard of living and well-being independently of the level of market implication. If people can live a good life regardless of market implication (Gerber & Gerber, 2017), they can be protected from shifts caused by transition policies, such as sectorial phase-offs and reconversions. A WS is an ally to the establishment of an ES, not because of its economic foundation, unlimited growth, which can be unsustainable, but because of this ethical foundation (Eklind Kloo, 2015), which contributes to shifting the justice criterium from subjective preference to human need (Bohnenberger, 2020; Brand-Correa & Steinberger, 2017; Gough, 2017; Koch, Buch-Hansen, & Fritz, 2017).
- A low social stratification. The reduction of inequalities because of the redistribution of income is a key element also from an environmental viewpoint (Koch, 2013). The resultant low stratification allows the sharing of power, therefore potentiating the procedural dimension of just transitions (Eklind Kloo, 2015), where everyone can consequently participate in social-environmental decision-making in equal conditions.
- Strong democracy, which proclaims procedural and restorative justice, so that individuals can participate in equal conditions in the transition and are compensated for any damage to their interests and rights, as recognised by democratic institutions. Strong democracies perform better in environmental terms (Jakobsson et al., 2018; Ramalho, Neves Sequeira, & Serra Santos, 2018; Thombs, 2019).
- A uniform, standardised and powerful local administration. The local level in the Nordic countries has been worthy of note since the 19th century. The energy crisis in the 1970s forced the mobilisation of domestic resources to reduce dependency and fuelled a transition to a model of competence with a greater regional power. This model of competence, jointly with the subsequent potentiation of local resources, built the foundations for decentralised and sustainable energy systems based on renewables (Westholm & Beland Lindahl, 2012).

- A public discourse on ecological modernisation that pictures a sustainable transition as an opportunity to grow (Büchs & Koch, 2017; Dryzek, 2008; Gough et al., 2008).
- The parallelism between the implementation of WS and the transition to ES at a political level (Gough, 2016). Both are rooted in social justice (Jakobsson et al., 2018) and introduced to solve inefficient situations that theoretically markets cannot solve on their own. Likewise, both are responses to long-term social shifts that face notable economic and political limitations (Meadowcroft, 2008). In addition, as WS are functioning structures, environmental measures are provided through them (Koch & Fritz, 2014; Meadowcroft, 2012).
- The prioritisation of low-intensity services, notably care (Eklind Kloo, 2015), over other activities with higher resource intensities, contributes to reducing the use of environmentally harmful resources and their overexploitation.
- Assimilation of environmental measures to social measures. As climate change and environmental deterioration threaten the livelihood of the planet and the standards of living, environmental policies can be seen as social policies if they face the effects of natural disasters, compensate for the regressivity of transition policies (Bailey, 2015) and protect low-income individuals, who suffer environmental deterioration more harshly (Dryzek, 2008).

According to these drivers, WS can both facilitate and hinder the transition to ES (Table 4-1).

Table 4-1 Fields of synergy and conflict between WS and ES corresponding to theoretical drivers of synergy

Drivers	Synergy WS-ES	Conflict WS-ES
Decommodification	Ethical foundation for an alternative model. Protection against rearrangements in markets during the transition	Welfare requires continuous economic growth that can be environmentally harmful
Low social stratification	Procedural justice	Regressive environmental policies. Redistribution of

		income can increase emissions
Strong democracy	Procedural and restorative justice	No detected discordance
Powerful local level	Mobilisation of domestic resources, reduction of dependency and decentralisation	No detected discordance
Public discourse on ecological modernisation	Positive social perception of environmental initiatives	Continuous growth, even if green, can neglect planetary boundaries
Parallelisms WS-ES	Institutional structures and experience	Scopes and risks differ. Competition for public funds
Prioritisation of low-intensity services	Reduction of resource intensity and dematerialisation	The promotion of services is relatively limited, since industry and agriculture are essential to meet needs, demand services directly and generate income to spend indirectly on services. Not all services display a low resource intensity, e.g., transport.
Assimilation of environmental policies to social policies	Adaptation, mitigation, progressivity	Competition for public funds

Source: Own elaboration.

To our knowledge, just five works have studied the empirical corroboration of synergy, with different methodologies and variables (Table 4-2). The proper empirical discussion emerges in 2014 (Koch & Fritz, 2014). Koch & Fritz (2014) rely on the canonical classification of WS (Esping-Andersen, 1990) to crosscheck the social and environmental performance of countries in 1995 and 2010. Through a correspondence analysis of centroids, they conclude the independence between welfare and the environment. Those countries with higher social assistance are also the ones with higher GDP and ecological footprints. Nevertheless, Sweden and Austria seem to verify the

hypothesis. The authors also analyse whether different institutional configurations determine the attitudes of citizens regarding social and environmental policies. By clusters, but focusing on attitudes, Conservative WS show the best environmental results. Accordingly, they reject the hypothesis but cannot completely discard that Social-democratic WS have contributed to the development of ES as the nexus between WS and ES is more complex than expected.

Another work explores public support for environmental and welfare policies as a facilitator of Eco-social States (Jakobsson et al., 2018) and finds no evidence of synergy: Conservative and Liberal WS perform similarly to the Social-democratic ones. As stated by its authors, the weaknesses of focusing on polls are two: attitudes do not reflect real policies nor real welfare, and data come directly from individuals, therefore introducing subjectivity.

More recently, Fritz & Koch have revisited the hypothesis (Fritz & Koch, 2019). Insisting in a correspondence analysis over perceptions, the Social-democratic States combine higher rates of support for climate and welfare policies with poorer environmental performances. Together with Sweden, Conservative WS like Germany and Switzerland arise as supporters of environmental measures.

Another work devoted to mapping Eco-welfare States through hierarchical clustering (Zimmermann & Graziano, 2020) observes that the Nordic States perform above average both in social and environmental terms, therefore considering the hypothesis verified. Nonetheless, since the characterisation of countries is posterior to the clustering, the authors warn that this result is descriptive and limited. Likewise, the mechanisms of synergy remain unknown.

A final work relies on polls and descriptive variables to perform a multinomial regression model (Otto & Gugushvili, 2020). It coincides with previous analyses in pointing to the Nordic States as places of concurrence of elevated support for climate and social policies.

From these works, we extract four conclusions:

First, they try to cluster countries to test the correspondence between social and environmental dimensions.

Second, analyses mostly focus on the study of individual attitudes. Objective indicators, i.e., those that aspire to measure real welfare and environmental performances instead of attitudes or opinions, have only been used in two works (Koch & Fritz, 2014; Zimmermann & Graziano, 2020).

Third, regarding WS, the classification proposed by Esping-Andersen, or a near notion of it, lies beneath most of the studies and overlaps with other classifications about

the relationship between contemporary capitalisms and the environment (Cahen-Fourot, 2020; Wood et al., 2020).

Fourth, works propose diverse variables (Table 4-2), notably attached to GDP, but avoid a discussion about such a selection and its implications. Previous papers perceive the drivers of synergy as merely contextualising ideas, instead of precise elements that should be aligned with their methodological choices, and select their own variables to test it. These works do not explain the reasons behind such differing choices nor interpret their results conditioned to them. Since those drivers were previously determined in this Section, we can establish a correspondence with the variables or set of variables proposed to study it (Table 4-2). To simplify, we call "set of variables" to collections of variables related to opinion polls, given their extension and lesser relevance to this work, as argued in the following paragraphs.

Table 4-2 reveals that previous studies do not cover all the drivers of synergy, but analyse variables that are not linked with them. Such drivers as the local administration, the parallelisms WS-ES and the assimilation of environmental and social policies have never been used to define variables. Such variables as GDP, attitudes and public opinions, sociodemographic variables, union density, population and poverty do not correspond to a driver.

The drivers can be tested through objective indicators, without relying on opinion polls, which present the abovementioned limitations (Jakobsson et al., 2018). To be coherent, we exclude all subjective variables. Nonetheless, we have detected one exception: the inclination to pay for environmental protection relates to ecological modernisation: if citizens perceive environmental protection and modernisation as mutually reinforcing, they may accept higher environmental taxes.

This disarrangement is probably caused by the clustering rationale proposed in the cited contributions, which approach synergy as a correspondence between social and environmental dimensions, given the listed variables (Table 4-2). Yet, theoretical developments follow a causal chain based on the traits of WS that facilitate ES. If we follow the latter, the causes of synergy originate in the social dimension under a WS. These would deliver social results that concurrently serve as pre-conditions, i.e., causes, of the ES. These secondary causes would deliver environmental results. Coherently, we can identify variables related to causes and results, as well as intermediate variables (Figure 4-1). The latter represent a nexus between dimensions and constitute an approximation to the mechanisms of the synergy, because causal and result variables merely contextualise the initial and final socio-environmental status. By identifying intermediate variables, we could further the knowledge of such mechanisms, which

remain unclear, as concluded by Fritz & Koch (2014) and Zimmermann & Graziano (2020).

This review has determined the drivers of synergy, the variables selected to verify it in empirical works and the disarrangement between the two visions, hence providing an initial screening of variables (Table 4-2).

4.2. Solutions to the shortcomings of indicators and previous omissions

Regarding the remaining variables (Figure 4-1 A), we can still refine them by identifying additional shortcomings:

First, provided that decommodification is a driver, referencing magnitudes to GDP is contradictory. As the dimension of the market itself, its inclusion is against the possibility of individuals to live a good life regardless of their implication therein. Furthermore, there is a vast discussion about the shortcomings of GDP as a measurement of notions other than economic production (Bergh, 2009; Kalimeris, Bithas, Richardson, & Nijkamp, 2020) and the barriers to alternative calculations (Hoff, Rasmussen, & Sørensen, 2020). The GDP is strictly the monetary measurement of final goods and services produced within a country. Thus, it does not reflect real welfare. We suggest focusing on the generosity index, which provides a measure of the institutional provisions of national welfare policies that is systematically comparable between countries in long periods (Scruggs, 2014; Scruggs, Detlef, & Kuitto, 2017), and maintain the welfare effort, i.e., the social spending as a percentage of the GDP, as a mere indicator of public services. Welfare effort, which can be also problematic given that it is a ratio over the GDP, is used here as a supporting measure due to the restricted availability of the generosity index in recent periods (Section 4.3). For its part, the share of green taxes over GDP as a proxy for environmental regulation is avoidable, as the energy renewability already approaches strictness and the prerequisite of regulation. Equally, it serves to avoid the subjectivity introduced by the inclination to pay for environmental protection connected with ecological modernisation. As the deployment of renewables combines environmental concerns and technology, it is also a proxy for such a driver.

Second, the Gini index is applied as an indicator of stratification (Koch & Fritz, 2014; Zimmermann & Graziano, 2020), but it does not offer greater information regarding income strata, solely about the overall situation of inequality. Conversely, income ratios, like the 80/20 share or the Palma ratio, get closer to this notion as they picture the situation of the tails of the income distribution, i.e., of the most favoured and the least favoured individuals, where the relevant dynamics of inequality take place (Palma, 2014). Besides, we have identified the level of protection of workers as an additional variable that also affects democracy in the same sense that stratification operates: if workers, who are among the most affected stakeholders of the transition

(Gambhir et al., 2018), are protected, they can participate and shape decision-making in equal conditions. To simplify, given this coincidence, we consider that income ratios approach cohesion and justice in the sense that the driver of strong democracy suggests (Jakobsson et al., 2018; Ramalho et al., 2018; Thombs, 2019).

Third, the inclusion of the ratio services/industry is misaligned with its corresponding driver, which requires the proliferation of low-intensity services promoted by WS. Conversely, services in general, both high-intensity and low-intensity as inputted in the ratio, include such intensive activities as transportation and housing and their indirect activities, like the deployment of infrastructures (Fix, 2019). Assuming that public provisions are of low environmental intensity is inaccurate. Public services and investments are responsible for notable emissions and employments of resources in current WS because of the high intensity that some of their activities require (Ottelin, Heinonen, & Junnila, 2018). We suggest sticking to indicators of emissions and materials, since this driver focuses on the decarbonisation and dematerialisation of the economy, including the direct, indirect and induced impacts of public activities.

Fourth, the strictness of the environmental policy is difficult to quantify accurately and subject to four challenges (Botta & Koźluk, 2014). First, the multidimensionality of environmental regulations, policy instruments and administrative levels. Second, the difficulty of sampling to quantify it through perceptions in surveys, similarly to the issue of subjectivity in the tests of synergy. Third, the identification of the effects of these measures in a sea of policies and institutional configurations. Fourth, the limited availability of comparable data.

Botta & Koźluk (2014) discussed the different methods to tackle these challenges and subsequently created a composed indicator of Environmental Policy Stringency (EPS), which was used afterwards by Zimmermann & Graziano (2020) to test synergy. The EPS evaluates the presence of taxes over GHG, trading schemes, feed-in tariffs, deposit-refund schemes, standards of emissions and public subsidies for research about renewables. Despite its contribution to this discussion, the EPS is subject to limitations, as recognised by its creators. It is sensitive to the weight of its mentioned integrating factors, simplifies multidimensionality and has a narrow focus on the energy sector and few political instruments. Moreover, it is not available for all countries, not even in the OECD, as the large time-series required for observation. Furthermore, it does not measure the resultant environmental outcomes, solely the effect of the limited policies that it observes. Consequently, we support again the inclusion of indicators of emissions and materials, as direct evidence of such environmental outcomes.

The seats in the national Parliament obtained by green parties, also proposed by Zimmermann & Graziano (2020) in this sense, is scarcely meaningful for two reasons.

Firstly, all political parties have an environmental ideology and considering that of the greens to be the most representative in the final political outcome is a limited assumption. Green parties are of recent creation (Carter, 2015). In general, Social Democracies set up the WS under study. Also, other parties share positions with them, as proven by the government alliances in many countries, e.g., Sweden. Secondly, a driver of synergy lies in the local administration (Westholm & Beland Lindahl, 2012), so national Parliaments provide little information.

Fifth, the use of the Environmental Performance Index (EPI) under the time series format required by analyses is not recommended. The goal of the EPI is to provide a national score and a country ranking about the establishment of environmental targets through the combination of environmental performance indicators. The score is dependent on the number, typology and updating of its component indicators, which have ranged from 25 in 2008 to 20 in 2016 to 32 in 2020, for instance. These methodological rearrangements impede the assembly of data to generate time series and panels (Yale Center for Environmental Law & Policy, 2020).

Sixth, the Domestic Material Consumption (DMC) and GHG emissions pale in comparison with the material (Wiedmann et al., 2015) and carbon footprints (Hertwich & Peters, 2009), respectively, especially recommended by Ecological Economics and degrowth literature (Weiss & Cattaneo, 2017). The DMC measures the raw materials apparently, not finally, consumed per year within a country and is subject to the omission of upstream international transactions of raw materials and products. For its part, the GHG focuses on the aggregation of emissions by emitting economic activities in a country. The advantage of footprints is the detection of relevant material requirements (Zhang, Chen, Liu, & Zhu, 2017) and CO_2 residues of international trade (Xu, Dietzenbacher, & Los, 2020). Hence, picturing the environmental situation also from the point of view of consumption and capturing the behaviour of countries beyond their borders. ES reduce their footprints by increasing energy renewability, but also by closing the material cycles through recycling, hitherto omitted despite this relevance. Thus, we suggest the introduction of recycling rates of municipal waste as an approximation, given that long series of recycling rates for key materials are unavailable.

Table 4-2 Variables used in the literature and associated drivers of synergy

Variable	Reference	Dimension		Driver								Unrelated to the drivers	
		Social	Environmental	Decommodification	Stratification	Democracy	Local admin.	Ecological modernisation	Parallelisms	Services	Assimilation	Contextualising	Unlinked
Welfare effort	Koch & Fritz (2014)	X		X									
(Long-term) Unemployment rate	Zimmermann & Graziano (2020)	X		X									
Gini index	Koch & Fritz (2014), Zimmermann & Graziano (2020)	X			X								
Protection of employees	Zimmermann & Graziano (2020)	X			X	X							
Inclination to pay for environmental protection	Jakobsson et al. (2018)		X					X					
Ratio services/industry	Zimmermann & Graziano (2020)		X							X			
Ecological footprint	Koch & Fritz (2014)		X									X	
CO_2 or GHG emissions	Koch & Fritz (2014), Otto & Gugushvili (2020),		X									X	

	Jakobsson et al. (2018)												
Renewability of energy mix	Koch & Fritz (2014), Zimmermann & Graziano (2020)		X									X	
Share of green taxes over GDP	Koch & Fritz (2014)		X									X	
EPI	Zimmermann & Graziano (2020)		X									X	
DMC	Zimmermann & Graziano (2020)		X									X	
Strictness of environmental policy	Zimmermann & Graziano (2020)		X									X	
Seats in the national Parliament obtained by green parties	Zimmermann & Graziano (2020)		X									X	
GDP and GDP PPP	Jakobsson et al. (2018), Zimmermann & Graziano (2020), Koch & Fritz (2014), Otto &	X											X

	Gugushvili (2020)												
Acceptance of statements about state intervention and voluntary frugality	Koch & Fritz (2014)	X											X
Attitudes regarding income distribution	Jakobsson et al. (2018), Otto & Gugushvili (2020)	X											X
Sociodemographic variables	Jakobsson et al. (2018), Otto & Gugushvili (2020)	X											X
Public opinions from the European Social Survey (ESS)	Fritz & Koch (2019), Otto & Gugushvili (2020)	X											X
Union density	Zimmermann & Graziano (2020)	X											X
Population	Jakobsson et al. (2018)	X											X

Poverty rate	Otto & Gugushvili (2020)	X											X

Source: Own elaboration.

Finally, we must cover the drivers not studied in previous analyses:

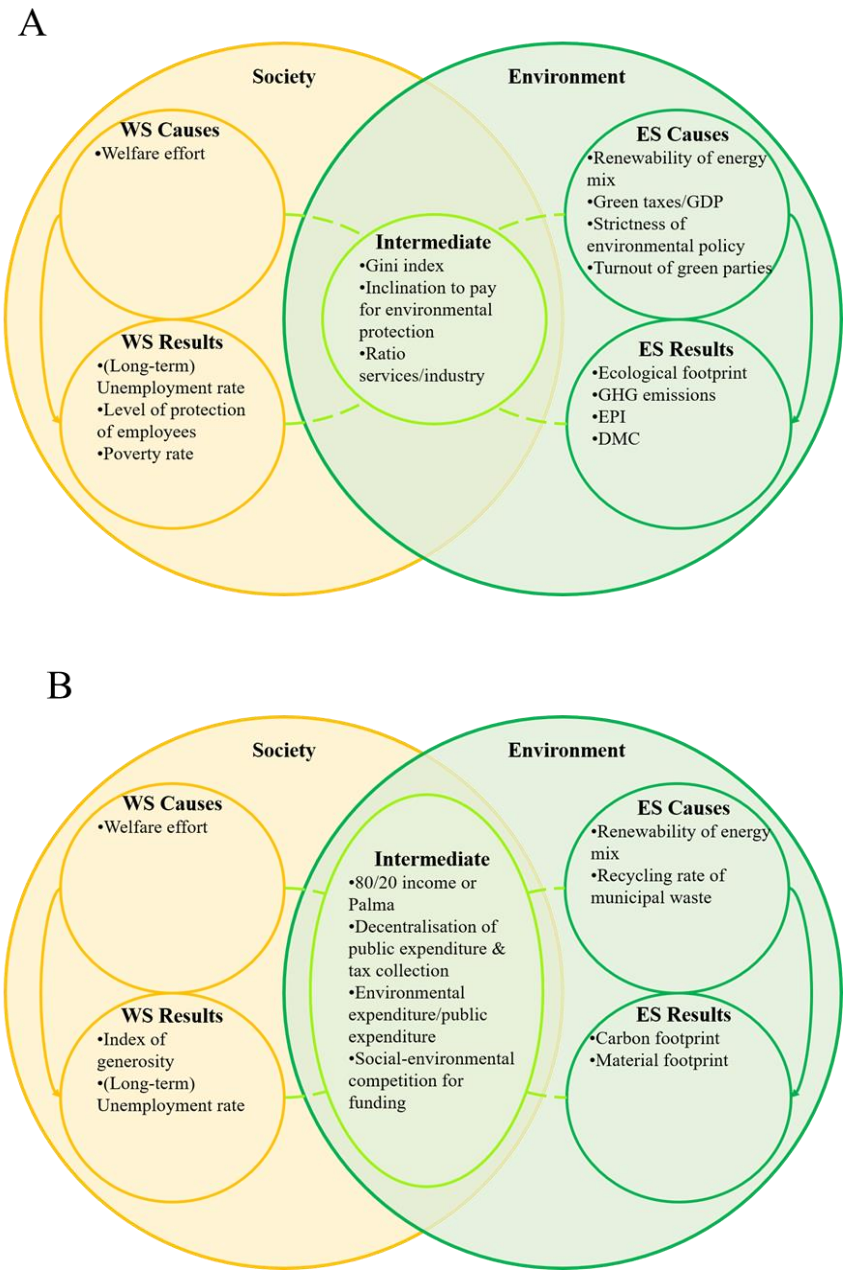
To measure the local administration, we propose the decentralisation of public expenditure, i.e., the share of public local expenditure over the total administrative expenditure, and its analogue: the decentralisation of tax collection. These variables reflect relatively the capacity of local administrations to collect their financial resources and spend them in their political programmes, thus indicating their proportional capacities against the other government levels.

To introduce the parallelisms WS-ES, we suggest the share of public environmental spending over total public expenditure, provided that environmental expenditure is the most representative environmental measure that flows through WS. In addition, we have designed a categorical binary variable to measure potential competition for funding. It is equal to 1 when social and environmental expenditure evolves interannually in a contrary sense, or if the increase (decrease) in social spending is higher (lower) than the increase (decrease) in environmental spending.

Regarding the assimilation of environmental and social policies, the two previous variables also match this driver. On the one hand, public environmental spending can be perceived as social spending in ES, as indicated in Section 4.1. On the other hand, the assimilation of environmental and social policies should prevent fiscal competition, potentially detected by the proposed binary variable.

Consequently, our proposal is shaped in Figure 4-1 B.

Figure 4-1 A: Classification of the variables proposed in the literature, excluding variables unlinked to drivers compared with B: this proposal under the theoretical causal rationale



Source: Own elaboration.

Comparing former proposals (Figure 4-1 A) and ours (Figure 4-1 B), we deepen the consideration of intermediate variables, while simplifying the characterisation of the status of social and environmental dimensions through fewer but more complete indicators.

4.3. Data and methodology

Comparability is mandatory in determining the sample and the methodology to explore how results vary in comparison with former works. Considering the sample, we

adhere to Koch & Fritz (2014) and Zimmermann & Graziano (2020), with some exceptions. We introduce Iceland, omitted from both analyses despite its importance for welfare, energy and environmental studies and exclude the Asian countries because of their institutional disparity with the rest of the sample.

In contrast to previous research and to enhance robustness, we suggest the continuous observation of clusters to avoid the consideration of precise years that could limit understanding, e.g., 1995 and 2010 (Koch & Fritz, 2014), 1993, 2000 and 2010 (Jakobsson et al., 2018), or 2016 (Fritz & Koch, 2019; Otto & Gugushvili, 2020; Zimmermann & Graziano, 2020).

The data sources used are shown in Table 4-3.

Table 4-3 Variables and data sources

Variables	Data sources	References
Welfare effort	OECD	(OECD, 2020g)
Generosity index	CWED 2	(Scruggs, 2014; Scruggs et al., 2017)
Long-term unemployment rate	OECD	(OECD, 2020c)
Unemployment rate	OECD	(OECD, 2020h)
80/20 income share	OECD, EUROSTAT	(EUROSTAT, 2020; OECD, 2020b)
Palma ratio		
Local expenditures	OECD	(OECD, 2020d)
Local revenues		
Environmental expenditure	OECD	(OECD, 2020a)
Potential competition for funding	OECD	(OECD, 2020d, 2020g, 2020a)
Renewability of the national energy mix	OECD	(OECD, 2020f)
Recycling rates of municipal waste	EUROSTAT	(EUROSTAT, 2021)
Carbon footprint	Eora MRIO	(Lenzen, Moran, Kanemoto, & Geschke, 2013; Moran, Kanemoto, & Geschke, 2020)

Material footprint	SDGs Database, OECD	(OECD, 2020e; UN Stats Open SDG Data Hub, 2020)

Source: Own elaboration.

Because of the unavailability of comparable data, some of the variables and countries are problematic:

- The generosity index is unavailable from 2010 and for Eastern European countries, Estonia and Iceland.
- The Palma ratio presents a discontinued calculation.
- In Australia and the US, local public budgets are aggregated under the general government.
- In Canada and New Zealand, there are no comparable data about expenditure, and the US registers "zero" environmental spending, therefore constituting an outlier.
- The material footprint is unavailable for the Czech Republic.

To deal with these limitations, we propose:

- Using the welfare effort as a proxy for public services and subsequently, the generosity index in the available cases, with the additional possibility of observing potential differences between the two indicators.
- Excluding the Palma ratio, as we still have the 80/20 share of income as an indicator of social stratification.
- Sticking to European countries. Therefore, we substitute the data source of the 80/20 income ratio for EUROSTAT to obtain a longer series (EUROSTAT, 2020).
- Excluding the material footprint and using the carbon footprint instead, as both are highly correlated (+0.9) (Table 4-4).

Regarding the methodology, we stick to the techniques used in the range of objective indicators. Koch & Fritz (2014) performed a correspondence analysis, while Zimmermann & Graziano (2020) carried out a hierarchical clustering. We prefer the latter, as we are not using as many categorical variables as Koch & Fritz (2014).

Clustering algorithms are diverse and four main approaches can be distinguished to simplify: centroid-based, density-based, distribution-based and hierarchical.

- Centroid-based algorithms classify individuals based on a centre, determined by the user, whose criterium significantly influences the results.
- Density-based calculation provides clusters by connecting parts of the sample that present a high concentration of observations based on arbitrary distributions, therefore resulting weak in cases of varied data and dimensions.
- Distribution-based approaches fit observations into clusters by assigning a specific distribution.
- In contrast, hierarchical algorithms generate a taxonomy of observations without formulating initial suppositions about centres or distributions and such a taxonomy does not undergo modifications in reiterated executions, hence reinforcing consistent and objective results. Ward's method is the most common and accepted variety of hierarchical clustering.

Despite hierarchical algorithms downgrade subjectivity, they face a relevant challenge. As they provide an open taxonomy, there is a necessity to divide such a taxonomy into proper clusters. Frequently, this division is made by the user based on personal preferences and analytical needs. If this arbitrary procedure is applied to the results of the clustering, the potential strength of reducing subjectivity is eliminated.

We follow Ward's Method in squared Euclidean distances because of its wide acceptance and apply Thorndike's criterium to find the optimal formation of clusters and prevent arbitrary divisions.

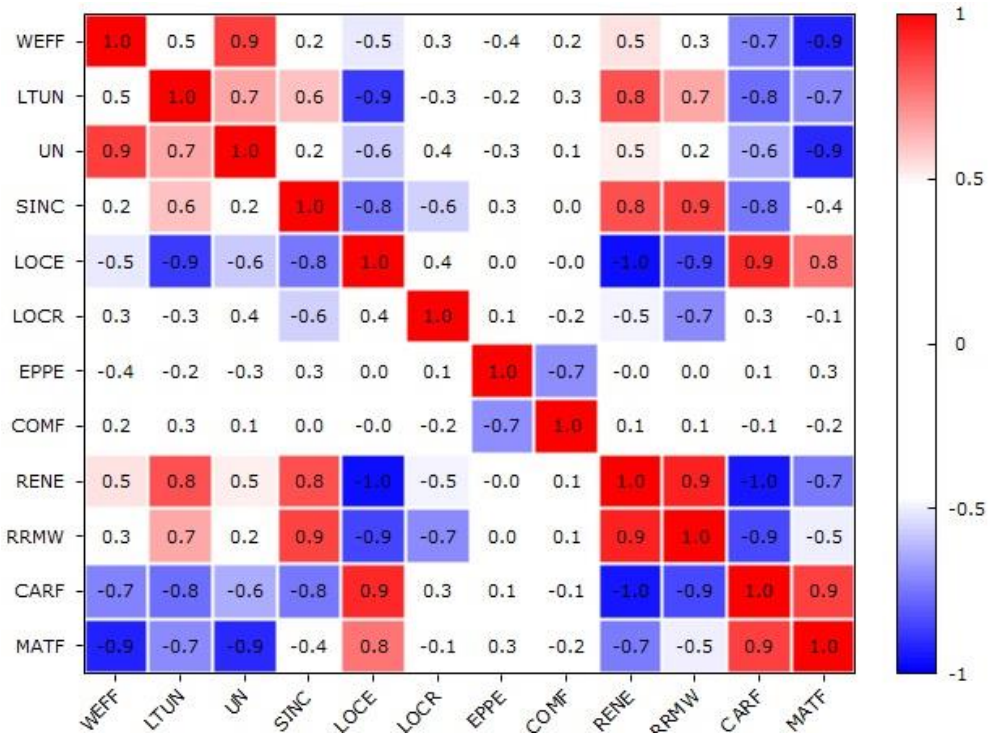
First, given that we are dealing with a clustering algorithm, identifying correlated variables is crucial. Clustering aims at determining internally homogenous groups of countries based on the variables that characterise their social-environmental situations and mechanisms. Correlated variables that belong to the same dimension (social or environmental) are therefore duplicated characterisations that unnecessarily enlarge the effort to execute the algorithm and could induce severe errors due to the overlapping of redundant information.

Based on high correlations (Table 4-4), we can omit the long-term unemployment rate because of a high correlation with the indicator of stratification (+0.6), the unemployment rate because of a very high correlation with the welfare effort (+0.9), and the renewability of the national energy mix and the recycling rates due to their very high correlations with the carbon footprint (-1.0 and -0.9, respectively).

Also, the correlation has provided two supplementary results. Local public expenditure and tax collection are inversely correlated with social stratification. Such a

correlation could be spurious, as the Nordics are the sole countries that combine both circumstances, because of this factor or another. The welfare effort and social stratification are inversely correlated with the carbon footprint. As the welfare effort is referenced to the GDP, its reduction, with the subsequent increase in the coefficient, diminishes carbon emissions. The negative correlation between stratification and the footprint suggests that the more equal states are also the most emitting countries. Again, the Nordic countries, the most equal and emitting countries, take the calculation to the extreme.

Table 4-4 Correlation matrix



Source: Own elaboration.

Second, we execute the clustering algorithm with the remaining variables standardised in z-scores, as they present different units. As the sample only overlaps between 2008 and 2016 and the availability of the generosity index is restricted, we propose an analysis in two stages. Initially, we cluster the total sample without the generosity index to obtain an overview from 2008 to 2016. Afterwards, we repeat the clustering for those countries for which the generosity index is calculated from 2008 to 2010. Otherwise, we would only be able to have a small sample of Western European countries between 2008 and 2010, insufficient for our purpose and biased because of the crisis. This focus allows us to test the hypothesis in opposing conditions, through crisis and recovery. As a result, we obtain the annual dendrograms, a representation of different possibilities of aggrupation at different distances between groups.

In a third step, it is necessary to determine the precise clusters among the panoply of combinations in the dendrograms. Usually, the user does this determination subjectively. In this analysis, however, we are looking for the optimal number of clusters, as reflected by data, to reduce subjectivity and potentially obtain greater information about the functioning of social-environmental clusters and synergy. Following the rationale of the algorithm, optimality is determined here through Thorndike's criterium, which considers that the number of clusters that allows the greatest reduction of distances between groups is optimal.

Once the annual number of clusters and compositions are known, we have perceived the need to present them in a compact and consolidated way for all the considered years to infer further insights. To satisfy this need, we have built a concurrence matrix (C), which gathers the information provided by all the corresponding dendrograms. It shows the percentage of runs of the clustering algorithm in which countries, two by two (ij), appear linked along the period (t) for which clustering is successful (n), i.e., the probability of finding that two countries belong to the same optimal cluster in our sample. Because of data availability, all countries provide successful clustering along the considered sample (n=9), except for Iceland, whose data only overlaps between 2013 and 2016 (n=4). As the comparison is established between countries, two by two, C is a symmetric matrix: the probability of the concurrence between Austria and Great Britain is the same that between Great Britain and Austria. In mathematical notation:

$$i = AT, BE, CZ, \dots, CH, GB$$

$$j = AT, BE, CZ, \dots, CH, GB$$

$$t = 2008, 2009, 2010, \dots, 2015, 2016$$

$$c_{ijt} = \begin{cases} 1 \; if \; i \; and \; j \; belong \; to \; the \; same \; cluster \; in \; t \\ 0 \; if \; i \; and \; j \; do \; not \; belong \; to \; the \; same \; \; cluster \; in \; t \end{cases}$$

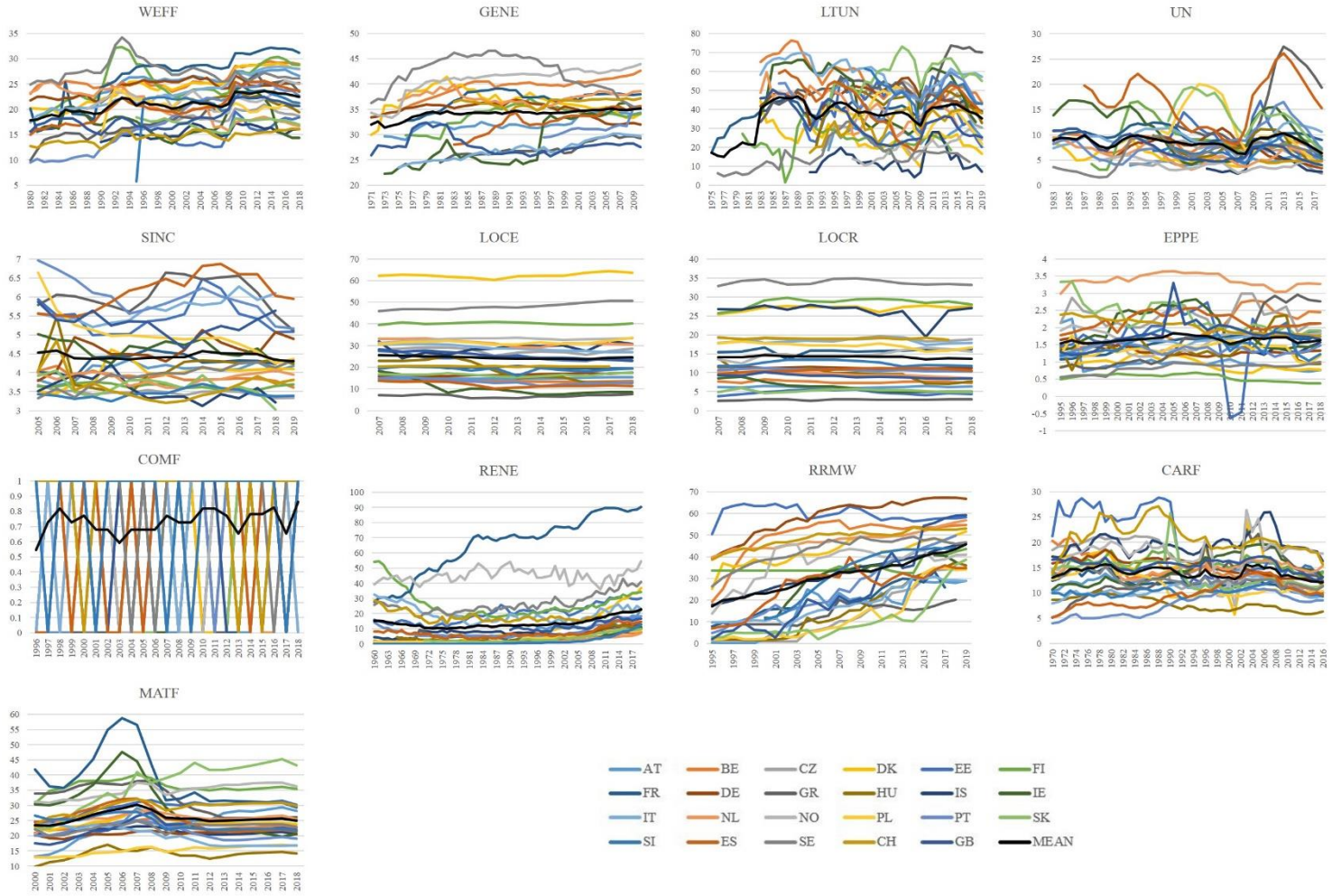
$$n_t = \begin{cases} 1 \; if \; successful \; clustering \; in \; t \\ 0 \; if \; unsuccesful \; clustering \; in \; t \end{cases}$$

$$C = \begin{bmatrix} \frac{\sum_{t=2008}^{t=2016} c_{AT,AT,t}}{\sum_{t=2008}^{t=2016} n_t} \cdot 100 = 100\% & \cdots & \frac{\sum_{t=2008}^{t=2016} c_{AT,GB,t}}{\sum_{t=2008}^{t=2016} n_t} \cdot 100 \\ \vdots & \ddots & \vdots \\ \frac{\sum_{t=2008}^{t=2016} c_{GB,AT,t}}{\sum_{t=2008}^{t=2016} n_t} \cdot 100 & \cdots & \frac{\sum_{t=2008}^{t=2016} c_{GB,GB,t}}{\sum_{t=2008}^{t=2016} n_t} \cdot 100 = 100\% \end{bmatrix}$$

4.4. Results

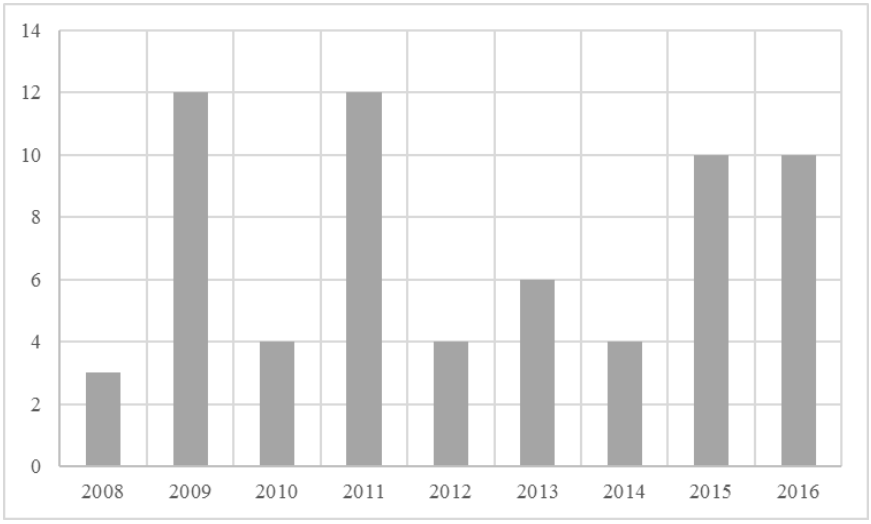
Concurrences prove that clusters are not stable, therefore reinforcing the need for dynamic observation. The number of optimal clusters increased during the crisis and stabilised afterwards (Figure 4-3). After the shock, the cyclical variables (welfare effort, unemployment rates and potential competition for funding) immediately reacted and generated increasing distances between countries, i.e., fewer clusters and lower concurrence scores corresponding to differential evolutions during the crisis (Figure 4-2).

Figure 4-2 Historical evolution of the variables considered to test synergy in the sample



Source: Own elaboration.

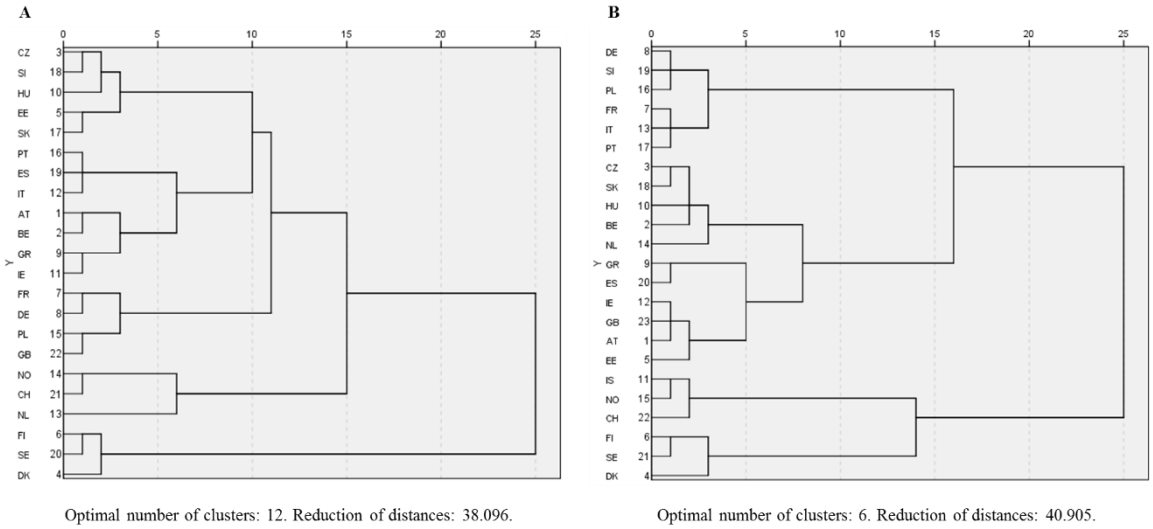
Figure 4-3 Optimal number of clusters by year under Thorndike's criterium



Source: Own elaboration.

To illustrate the instability of concurrences, we present the dendrograms of two selected moments: 2009 and 2013 (Figure 4-4). Figure 4-4 A shows the sharpest variation of concurrences due to the crisis, which manifests as fewer countries per cluster (12). Figure 4-4 B displays a situation of stabilisation after the shock, with larger clusters (6).

Figure 4-4 Annual dendrograms in the first calculation stage in 2009 (Panel A) and 2013 (Panel B)



Source: Own elaboration.

After transferring this information provided by the annual dendrograms into the concurrence matrix, it results as follows in stage one (Table 4-5).

Table 4-5 Concurrence matrix, without generosity index, 2008-2016

ID	AT	BE	CZ	DK	EE	FI	FR	DE	GR	HU	IS	IE	IT	NL	NO	PL	PT	SK	SI	ES	SE	CH	GB
AT	100%	33%	11%	0%	11%	0%	44%	22%	11%	22%	25%	44%	22%	0%	22%	22%	22%	0%	0%	22%	0%	11%	33%
BE	33%	100%	33%	0%	11%	0%	56%	33%	33%	44%	0%	33%	44%	22%	0%	33%	33%	33%	33%	22%	0%	0%	33%
CZ	11%	33%	100%	0%	11%	0%	22%	22%	11%	44%	0%	11%	11%	33%	22%	22%	11%	67%	56%	0%	0%	11%	11%
DK	0%	0%	0%	100%	0%	89%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	78%	0%	0%
EE	11%	11%	11%	0%	100%	0%	0%	22%	22%	0%	0%	22%	11%	22%	22%	22%	11%	22%	22%	22%	0%	22%	44%
FI	0%	0%	0%	89%	0%	100%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	89%	0%	0%
FR	44%	56%	22%	0%	0%	0%	100%	56%	11%	33%	0%	33%	56%	11%	11%	44%	44%	11%	22%	22%	0%	0%	33%
DE	22%	33%	22%	0%	22%	0%	56%	100%	22%	56%	0%	44%	67%	11%	0%	78%	56%	22%	44%	22%	0%	0%	56%
GR	11%	33%	11%	0%	22%	0%	11%	22%	100%	22%	0%	22%	22%	0%	0%	22%	22%	11%	22%	56%	0%	0%	22%
HU	22%	44%	44%	0%	11%	0%	33%	56%	22%	100%	0%	44%	44%	22%	0%	56%	44%	56%	44%	33%	0%	0%	44%
IS	25%	0%	0%	0%	0%	0%	0%	0%	0%	0%	100%	0%	0%	0%	75%	0%	0%	0%	0%	0%	0%	75%	0%
IE	44%	33%	11%	0%	22%	0%	33%	44%	33%	44%	0%	100%	44%	11%	0%	44%	44%	11%	22%	33%	0%	11%	56%
IT	22%	44%	11%	0%	11%	0%	56%	67%	11%	44%	0%	33%	100%	11%	0%	56%	78%	11%	33%	56%	0%	0%	44%
NL	0%	22%	33%	0%	22%	0%	11%	11%	0%	22%	0%	11%	11%	100%	33%	11%	11%	44%	33%	0%	0%	33%	11%
NO	22%	0%	22%	0%	22%	0%	11%	0%	0%	0%	75%	0%	0%	33%	100%	0%	0%	11%	11%	0%	0%	67%	0%
PL	22%	33%	22%	0%	22%	0%	44%	78%	22%	56%	0%	44%	56%	11%	0%	100%	56%	22%	44%	33%	0%	0%	78%
PT	22%	33%	11%	0%	11%	0%	44%	56%	11%	44%	0%	33%	78%	11%	0%	56%	100%	11%	33%	67%	0%	0%	44%
SK	0%	33%	67%	0%	22%	0%	11%	22%	11%	56%	0%	11%	11%	44%	11%	22%	11%	100%	56%	0%	0%	22%	11%
SI	0%	33%	56%	0%	22%	0%	22%	44%	22%	44%	0%	22%	33%	33%	11%	44%	33%	56%	100%	11%	0%	11%	22%
ES	22%	22%	0%	0%	22%	0%	22%	33%	56%	33%	0%	33%	56%	0%	0%	33%	67%	0%	11%	100%	0%	0%	33%
SE	0%	0%	0%	78%	0%	89%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	100%	0%	0%
CH	11%	0%	11%	0%	22%	0%	0%	0%	0%	0%	75%	11%	0%	33%	67%	0%	0%	22%	11%	0%	0%	100%	0%
GB	33%	33%	11%	0%	44%	0%	33%	56%	22%	44%	0%	56%	33%	11%	0%	78%	44%	11%	22%	33%	0%	0%	100%

Source: Own elaboration.

Regarding stable concurrences, the Nordic countries are the most exclusive. Denmark, Finland and Sweden only generate liaisons with each other. In contrast, Norway is the least selective. This extreme exclusivity implies that Sweden, Denmark and Finland are sufficiently far from other countries (including Norway and Iceland) but close to each other, despite shocks.

Conversely, there are very unspecific countries, such as Austria, Estonia and the Netherlands, which establish links with a diversity of countries.

We have elaborated the set of persistent concurrences and their profiles according to the average concurrence values for each variable since the described methodology minimises internal mean differences inside the concurrences. As synergy implies a comparative, we have applied conditional formatting based on the distance to the mean (yellow for average, greener for above average and redder for below average in positive traits, like the welfare effort, and on the contrary sense in negative traits, like the footprints) in order to observe how they compare at a glance (Table 4-6).

Table 4-6 Persistent concurrences and relative profiling

Concurrence	Countries	Social			Intermediate					Environmental			
		WEFF	LTUN	UN	SINC	LOCE	LOCR	EPPE	COMF	RENE	RRMW	CARF	MATF
1	DK	27.63	20.54	7.50	3.91	50.04	29.97	0.72	0.89	29.23	42.98	13.10	27.99
	FI												
	SE												
2	IS	17.96	24.64	4.58	3.47	27.08	19.85	1.64	0.70	50.08	39.52	18.64	33.14
	NO												
	CH												
3	CZ	20.01	50.58	8.82	3.54	20.86	12.26	1.98	0.74	10.57	22.91	10.97	32.36
	SK												
	SI												
4	NL	17.62	38.17	5.71	3.79	31.35	9.62	3.29	0.78	4.47	50.13	15.08	26.33
5	GR	24.84	49.61	20.15	6.27	9.24	6.83	2.17	0.78	10.99	24.36	12.86	26.40
	ES												
6	EE	17.07	41.72	9.69	5.51	24.46	4.88	1.38	0.78	14.91	23.04	14.50	26.35
7	BE	29.90	44.29	8.72	4.15	16.72	11.59	2.06	0.78	6.95	45.80	10.88	22.12
	FR												
8	AT	27.24	26.21	5.17	4.15	14.73	6.18	0.91	0.78	28.89	58.60	14.61	30.72
9	IT	25.86	52.73	11.37	5.80	21.21	14.65	1.52	0.67	18.61	30.46	9.51	19.34
	PT												
10	IE	21.36	41.92	9.43	4.89	17.81	7.73	1.79	0.83	5.69	39.03	14.59	23.66
	GB												
11	DE	22.51	41.99	7.81	4.51	22.24	12.75	1.42	0.78	9.94	36.10	9.76	17.11
	PL												
	HU												

Source: Own elaboration. WEFF – Welfare effort; LTUN – Long-term unemployment rate; UN – Unemployment rate; SINC – S80/S20 quintile income ratio; LOCE – Local government expenditure as a percentage of general government expenditure; LOCR – Local government revenues as a percentage of general government revenues; EPPE – General government expenditure on environmental protection as a percentage of public

expenditure; COMF – Potential competition for funding (1 if yes); RENE – Renewable energy as a percentage of the national energy mix; RRMW – Recycling rate of municipal waste; CARF – Carbon footprint per capita (T CO_2 per capita); MATF – Material footprint per capita (T per capita).

We derive the following insights:

First, contrary to previous research, we have not found a compact group as "the Nordics", but two well-differentiated groups: Denmark, Finland and Sweden on the one hand and Iceland and Norway on the other. The latter form a concurrence with Switzerland.

Second, concurrences do not follow the Esping-Andersen typology or its adapted versions (Koch & Fritz, 2014), e.g., the mentioned case of Switzerland (Conservative) with Norway and Iceland (Social-democratic), Belgium (Social-democratic) and France (Conservative), Portugal (Mediterranean) and Italy (Conservative), and Germany (Conservative) with Poland and Hungary (Eastern). This lack of alignment implies that the environmental dimension is unrelated to the typologies of WS. The classifications of WS are exclusively related to the social dimension and do not match the obtained eco-social typologies and the underlying performances of the environmental dimension or the behaviour of intermediate variables. Table 4-6 suggests that there is not an unambiguous approach, but diverse profiles that support the use of these eco-social concurrences instead of the former categorical WS classifications.

Third, the Nordics are socially paradigmatic, but the worst positioned in environmental terms: despite their above-average share of renewable energy (29.23% and 50.08%), they generate the greatest carbon (13.10 and 18.64) and material footprints (33.14) through average recycling rates (42.98% and 39.52%). Denmark, Finland and Sweden display the most remarkable local administration (local spending represents 50% of total spending), the highest level of potential fiscal competition for funding (89% of the years) and the lowest environmental spending (0.72%). Austria and the Netherlands, considered Social-democratic according to an updated version of Esping-Andersen's classification (Koch & Fritz, 2014) although Conservative in the original (Esping-Andersen, 1990), constitute individual cases but present an analogous behaviour, except for an average fiscal competition (78%) and a modest local administration, notably in Austria (14.73%). Nonetheless, the Netherlands does so through a welfare effort (17.62%) and energy renewability (4.47%) notably below the average, but with the greatest environmental expenditure (3.29%) and the second biggest recycling rate (50.13%). Belgium and France are responsible for the greatest welfare effort (29.90%). Yet they reach an average social performance and a better environmental profile. France is the main country responsible for this profile and behaves slightly better, even if

Belgium has moderately lower unemployment rates (7.92%) and stratifications (3.89). They also rely on a local administration with below-average importance (16.72%). We conclude that the Social-democratic regimes present the best social situations and the worst environmental results.

Fourth, the concurrence of the Czech Republic, Slovakia and Slovenia introduces an interesting profile. They show poor social performances, except for one of the lowest stratifications (3.54). Likewise, they register average renewability (10.57%) and the lowest recycling rate (22.91%) with one of the lowest carbon footprints (10.97) and one of the highest material footprints (32.36). The country responsible for this behaviour is Slovakia, an outlier regarding the disarray of footprints.

Fifth, the South shows the worst social performances despite an above-average welfare effort. As happened with the Nordics, there is not a single South, but two differentiated groups. While Greece and Spain display an average environmental performance, Italy and Portugal exceed, regardless of slightly above-average renewability (18.61%) and a below-average recycling rate (30.46%). In contrast, Greece-Spain registers the lowest local relevance (9.24%), while in Italy-Portugal it is average. As happened with the French-Belgium duo, high welfare efforts (24.84% in Greece-Spain and 25.86% in Italy-Portugal) appear with low social performances.

Regarding the last individual case, Estonia combines one of the poorest social performances, closely following Greece-Spain, and average environmental performance with well below-average renewability and recycling rates.

Sixth, the Liberal regimes from Ireland and the United Kingdom combine average and slightly below-average social performances, significant low renewability (5.69%), average recycling, but better footprints, notably regarding materials (23.66). They also register the second greatest competition for funding (83%).

Finally, the unexpected Conservative-Eastern concurrence of Germany, Poland and Hungary is the average social performer, but displays the second-lowest carbon footprint (9.76) and the lowest material footprint (17.11). The East is not isolated and approaches the Conservative regimes.

The inclusion of the generosity index (not correlated with the welfare effort) has caused few variations for the countries for which it is calculated from 2008 to 2010 ceteris paribus (Table 4-7): some Social-democratic regimes increase the concurrence with Conservatives and Liberals (Austria with France and Ireland, Belgium with Ireland, the Netherlands and Switzerland), Conservatives with Liberals (Germany with Ireland, Switzerland with Ireland) and Mediterranean with Liberals (Greece and the United Kingdom). Conversely, it increases the gap between Ireland and Greece. In consequence, this secondary exercise does not clarify concurrences.

Table 4-7 Variations in concurrences caused by the inclusion of generosity, 2008-2010

ID	AT	BE	DK	FI	FR	DE	GR	IE	IT	NL	NO	PT	ES	SE	CH	GB
AT	0%	0%	0%	0%	33%	0%	0%	33%	0%	0%	0%	0%	0%	0%	0%	0%
BE	0%	0%	0%	0%	0%	-33%	0%	33%	0%	0%	0%	0%	0%	0%	0%	0%
DK	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
FI	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
FR	33%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
DE	0%	-33%	0%	0%	0%	0%	0%	33%	0%	0%	0%	0%	0%	0%	0%	0%
GR	0%	0%	0%	0%	0%	0%	0%	-67%	0%	0%	0%	0%	0%	0%	0%	33%
IE	33%	33%	0%	0%	0%	33%	-67%	0%	0%	0%	0%	0%	0%	0%	33%	0%
IT	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
NL	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	33%	0%
NO	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
PT	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
ES	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
SE	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
CH	0%	0%	0%	0%	0%	0%	0%	33%	0%	33%	0%	0%	0%	0%	0%	0%
GB	0%	0%	0%	0%	0%	0%	33%	0%	0%	0%	0%	0%	0%	0%	0%	0%

Source: Own elaboration.

Thus, we reject the hypothesis of synergy for two major reasons:

First, the Social-democratic regimes present the best social and the worst environmental performances. The socially paradigmatic Nordic countries combine the greatest shares of renewable energy and average recycling rates with the greatest carbon and material footprints. Nordics are unable to translate the mobilisation of domestic resources and renewability into decarbonisation and dematerialisation. Public services represent relevant shares of such footprints, e.g., in Finland 19% and 38% respectively, mostly related to construction and infrastructures (Ottelin et al., 2018). A similar warning was already pointed out by Koch & Fritz (2014), but they concluded that Sweden (and Austria) verified the hypothesis. Even if Sweden is the best environmental performer in the first Nordic cluster, its footprints do not respond to renewability and recycling: France-Belgium registers similar carbon and material footprints (around 11 $MtCO_2$ and 23 T per capita, respectively) with a considerably lower renewable share (6.95% versus 35.67% in Sweden) and a slightly lower recycling rate (45.80% versus 47.77%). Likewise, the verification in Austria is rejected too.

Additionally, Denmark, Finland and Sweden do not potentiate the parallelisms between WS and ES, as they register the most remarkable potential competition for funding and the lowest public environmental expenditure. Contrary to Jakobsson et al. (2018) and Zimmermann & Graziano (2020), Conservatives and Liberals do not perform similarly to the Nordics, but better in average environmental terms, as Koch & Fritz (2014) noted.

Second, as concurrences do not match previous WS classifications, the results reflect a diversity of profiles and, as shown in Table 4-6, social and environmental dimensions are unrelated. There is not a single, univocal connection between the WS regimes, the intermediate variables and the situation of the environmental dimension. Instead, we find diversified portraits that require further discussion.

4.5. Discussion: fostering synergy through Sustainable Welfare

In light of these results, we want to acknowledge the limitations of our research, which points to some methodological and political fronts, and open the scene to future research of this topic.

The first clarification is that we have rejected synergy in this sample, with the cited variables applied to the feasible period. Improvements in data availability could enrich the interpretation of results, notably from now on, as data started to be fully available from 2008.

Second, our contribution is the alignment of the empirical-theoretical considerations and subsequent screenings of variables, about which few discussions have been proposed. To obtain comparable results, we have mimicked previous methods, while avoiding the assumptions concerning the classifications of regimes. In this vein, the road unfolds in two different but parallel ways.

Regarding clustering, there is a need to surpass categorical classifications as reality proves more complex. Additionally, synergy is a process of coevolution and, consequently, the discrete analysis provides little information. Besides, synergy as formulated in previous contributions is a matter of comparison. Nevertheless, synergy could also be defined in feasible social-environmental terms based on the profiles of countries or persistent concurrencies, as each of them displays a unique behaviour and a different panoply of possibilities, weaknesses, strengths, and threats.

Beyond Social-democratic WS, and with a cautionary approach given the diversity, we can observe some behaviours related to other concurrences. A Conservative WS like Germany joined by some Eastern regimes like Poland and Hungary present the best environmental performance with an average social performance. This a priori unexpected combination is unavailable in other concurrences: Mediterranean WS also have positive environmental situations but combined with the poorest social profiles, and Liberal WS maintain the average social performances close to the Conservative WS with slightly positive to average environmental circumstances. Furthermore, the German-Polish-Hungarian concurrence is unique in comparison with their typologies: not all Conservative and Eastern WS behave in this way. Worthy of mention among the Eastern regimes is the poor performance of the concurrence between the Czech Republic, Slovakia, and Slovenia. Future research should clarify this unique behaviour.

On the other hand, there is room for other methodologies. Simulation tools and systemic modelling have much to say in this respect. Yet, while looking at the future, research cannot forget the past. Improvements in the availability of metrics beyond GDP, such as the generosity index, beyond Gini, as with income shares and the Palma ratio, and footprints including biophysical-economic dynamics, could illustrate the joint evolution of social and environmental dimensions during past decades.

Third, quantitative contributions cannot relegate the qualitative-institutional discussion about the roles of the state (Vatn, 2020). Diversity suggests complex non-unidirectional ways of approaching synergies and conflicts. From this viewpoint, the potential mechanisms of synergy, i.e., the intermediate variables, must be more varied than those theorised.

Anyway, the central element in a conflict between WS and ES is the sustainability of economic growth, responsible for environmental deterioration and welfare support. The absence of synergy fuels the debate about transitions between green growth and post-growth, to simplify despite variety (Drews, Savin, & van den Bergh, 2019), and could well provide arguments to both sides. If a decoupled green growth was possible, the conflict would be immediately deactivated. Conversely, in a post-growth scenario, current WS will be placed on the edge of a precipice: as income decreases or stabilises, there is a need to strengthen the coverage of WS through public expenditure supported by revenues calculated over a decreasing or steady income, apart from other specific barriers (Strunz & Schindler, 2018). To face this, some streams suggest redistributing wealth apart from income (Koch, 2020). In parallel, degrowth demands strong democratic support to such challenging measures as the limitation of private property and the redistribution of working time (Cieplinski, D'Alessandro, & Guarnieri, 2021; Nieto, Carpintero, Lobejón, & Miguel, 2020).

When scholarship denies decoupling and realises the challenges of degrowth, it arrives at a crossroads that motivates the increasing momentum of SW to explore the environmental implications of WS. SW fosters the satisfaction of human needs (not preferences) within ecological limits from an intergenerational and global perspective (Koch et al., 2016) and unveils the internal contradictions of current WS to deal with the transition to ES (Hirvilammi, 2020). Its main tools are universal basic incomes, services and bonds, as well as job guarantee proposals, to increase freedom to determine one's own lifestyle, decommodify society and motivate transformation (Bohnenberger, 2020).

Our conclusions do not limit to synergy-facilitating SW based on the institutional characteristics of Social-democratic WS. In this regard, Universal Basic Services (UBS), which guarantee a socially agreed decent standard of living as a human right, could serve this goal (Coote & Percy, 2020). UBS are inspired by current universal services like

education and healthcare and promote further coverage to childcare, adult care, housing, food, transportation and digitalisation.

Since this thesis has argued the misalignment of environmentally intensive public services with the idea of dematerialisation in Section 4.2, the same problem can be attributed to UBS. For instance, in Coote & Percy (2020), universal housing is beneficial as it guarantees decent living conditions while decreasing emissions because of higher efficiency in new and renewed buildings. However, we cannot disregard the counterpart: the intensive consumption of resources to provide such efficiency and its environmental impact. As indicated by Ottelin et al. (2018), construction and infrastructures are responsible for most of the environmental footprints of WS. In addition, this study also points to the capacity of WS to improve the equity of the footprints through two mechanisms: 1) public services are increasingly used as income reduces, and 2) a significant share of the consumption in lower income deciles is achieved via public subsidies. WS have the possibility of compensating the environmental effects of redistribution through demand-side management policies for reducing natural resources consumption. Thus, a condition arises to provide synergy-facilitating UBS: the cancellation of their environmental impacts. The potential for this cancellation lies in their nature, in contrast with other tools. While redistributed income is consumed under individual criteria that can be environmentally harmful, as argued in Section 4.1, UBS operate under supervision based on social criteria. When the public sector, whether directly or indirectly, assumes the provision of UBS, there is an opportunity to cancel their environmental consequences if they are socially orientated towards the least resource-intensive conception of the service so that the eco-social benefits overweight their implicit environmental costs. Despite this potentiality, much remains to be said in this regard. Synergy and conflict between WS and ES in the frame of just transitions appeal to SW scholarship as they can offer facts and strategies to settle the debate.

This contribution could come from further theories and empirical applications of the main tools, such as UBS and Universal Basic Income (UBI), but also from downscaling. SW has adopted a macro approach and, hence, focused on global and national cases and proposals, as happened with the related field of just transitions. This thesis proposes a reflection on the potentiality of SW tools to be adapted and applied to rural areas that are undergoing the phase-out of fossil fuels and the restructuring towards renewables. This reflection arises from the experience of the Spanish context but is transferable to nearly any local transitioning context in developed countries, where the decline of fossils started almost three decades ago, and the resultant situation of socioeconomic deterioration looks nearly irreversible.

4.5.1. Potentiality and essential matters of UBI

A UBI is an unconditional regular payment to every member of society in adequate quantity to ease poverty and reinforce freedom (Raventós, 2007; Van Parijs & Vanderborght, 2017). This kind of universal and basic transfer is conceived as individual, unconditional, regular, predictable, stable, permanent, and non-withdrawable (Fletcher & Büscher, 2020). To illustrate this tool, we rely on the four criteria proposed by Büchs (2021), which also allow comparison with UBS: the potential for the satisfaction of needs, the respect of planetary boundaries, the capacity of distributive fairness, and the enhancement of democratic governance.

As far as the potential of UBI to satisfy human needs is concerned, the literature highlights its ability to decommodify society, strengthen the position of employees in labour negotiations, reduce interpersonal dependency, and ease bureaucracy and social stigma around welfare benefits. Decommodification is a driver of eco-social synergy (Eklind Kloo, 2015; Gough, 2016), as it protects people from shifts in markets during the transition and prevents environmentally harmful or intensive activities. The reinforcement of the position of employees (Wright, 2006) in the context of the energy transition is directly linked to the procedural dimension of justice (Jenkins et al., 2016; Williams & Doyon, 2019). Employees engaged in energy activities are frequently pictured as the main stakeholders of the just transition, as they are the first group to experience the effects of the restructuring, and they do it more harshly. Reinforcement of their position has also been pointed out as a desirable action to achieve a just outcome (Gambhir et al., 2018). The reduction of interpersonal dependency has effects on the gender dimension of transition (Cox, 2019), more notably in rural areas, as it precisely incentivises women to engage in key activities for just transition and look for higher educational qualifications, ever later in life, and men to engage in care. Therefore, UBI could blur the lines between traditional gender roles in these rural areas, which historically specialised in technical and masculinised work activities (MITECO, 2020).

Furthermore, a key advantage of the UBI beyond the context of the energy transition is the elimination of bureaucracy and social stigma (Büchs, 2021). Universality reduces bureaucratic work in the management of welfare and takes out of the equation the "requirement of proof" in the access to welfare benefits, i.e., demonstrating sensitive private issues such as the level of income, the conditions of livelihood, the characteristics of the household and family, inter alia, and all the subsequent verifications that can result intrusive and stigmatising since they are practised by unknown third persons, sometimes through a public process.

In contrast, UBI presents possible problems of social trust, market failure, and crowding out of welfare provision. Social trust problems are believed to arise when UBI beneficiaries do not choose to engage in socially useful activities that contribute to

sustainable well-being (Büchs, 2021). The conception of this problem uncovers a paternalistic view that could result in the introduction of conditionality (Atkinson, 1996), which would erode universality by definition. Furthermore, this income would be spent in markets of goods and services that are subject to market failures (Coote & Percy, 2020). The UBI could crowd out the current welfare provision in an uncertain way.

Regarding the planetary boundaries, there are numerous doubts about its real effects. On the one hand, the impacts of UBI on labour supply, employment levels, consumption (Oswald, Steinberger, Ivanova, & Millward-Hopkins, 2021), intensity in the use of resources, and the subsequent environmental influence are uncertain and have a serious potential to be counterproductive. On the other hand, there is high certainty about its potential to reduce conspicuous consumption (Boulanger, 2010), i.e., that orientated to showcase a distinguished social position. It is also thought to increase material throughput if it leads to a reinforcement of economic efficiency (Birnbaum, 2010) because of the disappearance of bureaucracy and the multiplicity and frequent complexity of current welfare benefits. However, there is the conviction that UBI per se will not change how people produce and consume (Andersson, 2010; MacNeill & Vibert, 2019). In consequence, the environmental effects, if positive, would be very limited.

Likewise, the correct way to finance such a tool is uncertain. If the fiscal systems evolve towards green paradigms in line with the ecological transition (Andersson, 2010; Van Parijs & Vanderborght, 2017), the monetary resources to fund UBI would be increasingly limited (Calder, 2010) as economic habits change due to environmental consciousness and incentives. This green taxation could also be regressive, as these schemes tend to impose a heavier burden on the most disadvantaged individuals (Büchs, Bardsley, & Schnepf, 2014). In consequence, the need to design compensatory mechanisms to tackle the limited funding and regressivity would discredit the potential benefits of reduced bureaucracy and increased efficiency. Despite these limitations, UBI is still conceptualised as one of the most interesting tools to support livelihood in post-growth scenarios in comparison with the weaknesses of current cash benefits (Birnbaum, 2010; Lawhon & McCreary, 2020; Van Parijs & Vanderborght, 2017) and new developments are specifically addressing the manner to fund it in a just way (Arcarons, Raventós, & Torrens, 2017; Torres López, 2019).

As far as distributive fairness is concerned, additional doubts emerge. Beyond the need for corrective mechanisms, some designs of UBI even disregard the financing through progressive taxes (Van Parijs & Vanderborght, 2017), so UBI could end up introducing a significant regressivity, whether through traditional or environmental taxes. Furthermore, the abolition of the current welfare benefits mainly affects low and middle-income individuals and households (OECD, 2017) and the outcome would be significantly dependent on the impact on real wages, which is highly uncertain (Calnitsky,

2020). Notwithstanding, it is believed to contribute to gender equality by supporting the autonomy of women (Cox, 2019).

Finally, in terms of democratic governance, the main advantage is the underlying promotion of a change in the individual's self-perceived role in society and a reduction in stress and anxiety derived from downgrading awareness of individual risk (Lawhon & McCreary, 2020). This reconsideration would theoretically improve green attitudes, promote political engagement (Casassas, 2016; Raventós, 2007), and reinforce support for sustainable policies, but the outcome is highly dependent on the reaction of labour supply (Büchs, 2021). Furthermore, the bargaining power of workers could be enhanced, with the subsequent effects on the democracy of workplaces (Gourevitch, 2016).

In brief, UBI faces some concerns despite its potential. It could end up incentivising consumption and, ultimately, market dynamics, which will be environmentally harmful if individuals do not orientate their actions voluntarily towards the most socially useful activities. A potential conditionality introduced due to a misalignment of this orientation would erode the basis of this tool, and the welfare system would not experience the evolution that sustainability requires.

4.5.2. A local derivation: CBI, between UBI and PES

Local fossil-based areas with valuable spaces for biodiversity have been a laboratory to test market-based instruments since their decline began some decades ago (Büscher, Dressler, & Fletcher, 2014; Corson, Campbell, & MacDonald, 2014; McAfee, 1999), and achieved unsatisfactory results (Büscher & Fletcher, 2015; Dempsey & Suarez, 2016; Dunlap & Sullivan, 2020; Holmes & Cavanagh, 2016; McShane et al., 2011). Yet, market-based instruments are commonly proposed, as happens with the CTJ in Spain (Ministry of Ecological Transition and Demographic Challenge, 2020e, 2020d, 2020a, 2020c, 2020b), analysed in Section 3.5. These market-based instruments promote as an alternative to fossil activities such enterprises as ecotourism, bioprospecting, biodiversity offsetting, wetlands banking, Payment for Ecosystem Services (PES), and reduced emissions through avoided deforestation and forest degradation (Fletcher & Büscher, 2020).

According to Fletcher & Büscher (2020), while these instruments are diverse, their rationale is concordant: they aim at applying market schemes to link monetary values to biodiversity and the associated opportunity costs of alternative land uses and to internalise social and environmental externalities. Inherently, they picture biodiversity as mere ecosystem services or natural capital, subsequently trying to conciliate the economic development of the concerned areas with environmental protection by assimilating the conservation of nature to income generation. Beyond the unsatisfactory results, two major conceptual problems can be attributed. First, on the side of production, they do not address

the causes of nature ravages during the expansion of the extractive industries in these areas, which were motivated by capital accumulation (Shaw & Waterstone, 2019). Second, on the side of consumption, they disregard the cause of the overconsumption of energy by wealthier individuals in cities, far from these areas, which requires further consideration (Büscher & Fletcher, 2020).

To tackle the social situation of the areas and the environmental impacts without incurring the described limitation of UBI and market-reliant instruments, some authors suggest the introduction of a Conservation Basic Income (CBI). CBI is an intersection between UBI and the PES that specifically addresses conservation areas. The proposal combines the strengths of both instruments while overcoming their weaknesses. By definition, CBI is an unconditional payment scheme that covers the basic needs of individuals located in conservation-critical communities (Fletcher & Büscher, 2020). It inherits the spirit of UBI and the specificity of PES and, according to Fletcher & Büscher (2020), is not incompatible with a future UBI deployment, but potentially complementary.

While CBI tries to overcome the limitations of UBI, it does not avoid the uncertainties around the design of the benefit. These uncertainties are (Fletcher & Büscher, 2020):

- The definition of the potential beneficiaries: Should CBI be granted to communities located in a geographical space that is conservation-critical or to users of conservation-critical resources?
- The restriction of unconditionality: Is it generally acceptable, or just in case of a manifestly better result? In this sense, the debate unfolds in two ways:
    - The temporality of belonging, if the criterium of definition is location: How long should the beneficiary have stayed in the area to be considered a member of a conservation-critical community? Five years seem to be a spread suggestion (Standing, 2017; Van Parijs & Vanderborght, 2017). Some authors fear the potential migration to conservation critical areas that this benefit could incentivise, therefore worsening environmental ravages. Yet, evidence of this phenomenon has been considered spurious (Hoffman, Fay, & Joppa, 2011).
    - The introduction of community engagement activities, or similar, to promote awareness of better social-environmental choices among beneficiaries. Is it acceptable? Some studies have observed that the mere label ‘Conservation’ in the title of the instrument can

direct individual choices to this end if the payment is unconditional (Benhassine, Devoto, Duflo, Dupas, & Pouliquen, 2015; Standing, 2017). Would the title be enough to motivate this environmentally friendly behaviour? Would the introduction of engagement activities as a requisite annul the power of words as an implicit incentive scheme?

- The adequate quantity of the benefit: The level of generosity is highly dependent on the context, but is there any minimum and maximum threshold that should be observed? If so, how do we determine it? The proposals that seek to establish a general rule for all contexts point to a quantity of one-quarter of GDP per capita (Van Parijs & Vanderborght, 2017) as long as it is higher than the minimum amount for healthy living, USD 5 per day (Hickel, 2017).

- The suitability of children to be beneficiaries, which is not a minor concern given the ageing and low fertility rates of these areas: Is there a minimum age to receive the benefit? If so, which? Is this consideration vulnerating the universality inherent to this instrument? If not, who should be the guardian of the benefit until children are responsible for their management? What age is appropriate to consider that they can manage themselves? Fletcher & Büscher (2020) suggest that the CBI should be given to the adult who is the main caregiver of the child, but no further details are provided regarding the age limit of this measure.

- How CBI should be funded: Is there a need to develop new and specific funding tools to support them? Is adequate funding achievable under the current fiscal configuration? Would it be enough to improve the current means of taxation? Proposals range from the redirection of resources from other current public programs and improved monitoring of potentially diverted revenues in tax heavens (Standing, 2017; A. Stern, 2017) to the use of carbon taxes (Standing, 2017), public bonds, grants from donors and patrons, insurance, fees, revenues from the sale of green manufactures and crowdsourcing (Büscher & Fletcher, 2020).

- The suitability of cash as a means and the need for further instruments of adequate allocation: Is the complementary introduction of UBS a reinforcing tool?

- Finally, if CBI generates further environmental damage, what are the compensatory mechanisms to address the unwanted results?

Beyond the design, there is concern about the viability of CBI to overcome one of the main critical points of UBI: the environmentally harmful behaviours caused by increasing income. Rising levels of income are correlated with environmental impacts (Caron & Fally, 2018), and unconditional monetary benefits have been linked in the short term with land clearing (Wilebore, Voors, Bulte, Coomes, & Kontoleon, 2019). However, we should consider a key element that UBI does not incorporate because of universality: the simple label "Conservation" in the unconditional welfare benefit has the potential power to direct an individual's behaviour towards this goal, as observed in similar benefits (Benhassine et al., 2015; Standing, 2017). Yet, some propose as a prerequisite to benefit from the CBI the establishment of community engagement activities to have greater certainty in social-environmental beneficial choices (Fletcher & Büscher, 2020), but again this premise would erode the essential unconditionality of the tool and the underlying search for freedom in the spirit of current theorisations about SW.

In coherence with these problems around income benefits, Fletcher & Büscher (2020) consider that monetary tools are useless in the absence of an effective provision of goods and services and orientate this discussion towards the "effectiveness of social services and infrastructure in target communities" (Fletcher & Büscher, 2020: 6), therefore, pointing to the capacity of UBS to complement CBI. Nevertheless, the authors also recognise the limitations inherent to UBS, which will be presented below, in connection with the work of Büchs (2021).

4.5.3. Potentiality and essential matters of UBS

A UBS is a provisioning system of unconditional services to every member of society to satisfy their needs as they arise (Büchs, 2021; Fanning, O'Neill, & Büchs, 2020). Following the mentioned criteria, we can assess this tool and put it in contrast with UBI.

In consonance with the criterium of satisfaction of human needs, UBS are in essence similar to UBI: they represent an income, this time virtual (Coote & Percy, 2020; Gough, 2019), which incentivises free time and engagement in meaningful activities. Yet, UBS are considered more efficient and effective than the market approaches promoted by monetarisation (Coote & Percy, 2020). UBS incentivise the demand for care workers and support stability in job opportunities. However, the bureaucracy linked to their provision could be irresponsive to individuals' real needs and again assume paternalistic approaches.

Concerning planetary boundaries, there are no higher certainties in comparison with UBI, as UBS are supposed to display comparable effects regarding employment, consumption, and therefore, environment. However, there is a key element to consider: the possibility for public providers to design UBS in the most environmentally

responsible way possible, by reducing their intensity and consequent environmental impact. This possibility, which is not inherent to UBS and highly depends on political decision-making, is not available in UBI without vulnerating unconditionality and consequently, incurring paternalism. The truly inherent trait of UBS is the potential to support the demand for workers in activities with lower environmental intensity and reduce the pressures of international competition (Coote & Percy, 2020; Foundational Economy Collective, 2018).

UBS are notably suitable to underpin post-growth contexts since they support livelihood without monetarisation. However, they could act at the expense of increasing the demand for energy and transportation among the most disadvantaged households due to the characteristics of their monetary consumption. Again, subsequent adjustments would be required at the top of the distribution to solve the environmental harm of this indirect response (Büchs, 2021).

Regarding the criterium of fairness, the outcome would be similar to UBI (also concerning real wages), but the implicit virtual income of UBS (OECD, 2017) would improve justice in the distribution of the capacity for need satisfaction compared to current cash benefits (Portes et al., 2017), and this distribution would be higher as taxes become more progressive (Gough, 2019; Verbist, Förster, & Vaalavuo, 2010).

Finally, according to the criterium of democratic governance, the impact would be similar to UBI, with an additional danger paradoxically related to a key advantage of UBS: the possibility of orientating their provision towards the less intensive conception of the service. This orientation, reliant on political decision-making, has the risk to incur paternalistic conceptions when addressing the needs and their satisfaction, and therefore, can be managed top-down, from political agents to individuals, without the active and conscious participation of citizens (Büchs & Koch, 2019; Gough, 2017). This is why some authors suggest that UBS must be designed to become user-led, co-produced, and democratically accountable (Coote, Kasliwal, & Percy, 2019; Coote & Percy, 2020).

4.5.4. A comparison of UBI and UBS and their (not so) conflicting nature

Given the criteria for characterisation and comparison of SW tools (Büchs, 2021), and provided that UBI and UBS show positive and negative consequences, a simplified comparison is shown in Table 4-8.

Table 4-8 Comparison of UBI (CBI) and UBS

Criteria	Effect	Instrument	
		UBI (CBI)	UBS
Satisfaction of needs	Positive	Reinforcement of the position of employees Reduction of interpersonal dependence Elimination of bureaucracy and social stigma	Virtual income: more socially efficient More stable jobs opportunities
	Negative	Problems of social trust: paternalism	Lack of responsiveness: paternalism
Respect of planetary boundaries	Positive	Reduction of conspicuous consumption Increasing efficiency due to a decreasing bureaucracy	Opportunity for an environmentally conscious design Promotion of low-intensity activities free of international competition
	Negative	Uncertain socioeconomic and environmental impact Insufficient per se to cause a behavioural change Problematic funding through environmental taxation: mechanisms for compensation	Design is highly dependent on political decision making Potential violation of unconditionality Side effect: increasing demand for energy and transport in low-income households: mechanisms for compensation
Fairness	Positive	Promotion of gender equality	Improvement of the distribution of the capacity for need satisfaction

			Highly progressive potential
	Negative	Increase in fiscal regressivity Potential higher impact on the most vulnerable	No negative effects detected
Democracy	Positive	Change in self-perception Reduction of stress and anxiety Promotion of political engagement and green policies	No additional effects detected
	Negative	The outcome is highly dependent on the labour supply	Paternalistic conceptions in the design of services

Source: Own elaboration.

A joint application of UBI and UBS has been judged as impossible due to diverse reasons, mainly a differing approach and competence for limited public funding (Coote & Percy, 2020).

Conceptually, UBI addresses consumption and shows a demand-led approach to welfare, and UBS are focused on the provision and subject to a supply-led conception. A priori, these differing philosophies should not imply an immediate incompatibility between both instruments. However, a section of the literature presents a potential conflict. This collision would theoretically derive from the process of application of these conceptions: while UBI requires the determination of a cash benefit to be transferred to individuals to freely allocate it, UBS precise identification of objective needs, elements of satisfaction, and design of provision. The core considerations of these two applications can be conflicting more clearly: UBI fosters a free allocation of resources that would ultimately result in a social-environmental useful result, while UBS seeks such a result in the first place. Therefore, there is a risk of paternalism implicit in UBS that cannot be translated into the framework of UBI without denaturalising the tool by denying unconditionality: a conditional UBI is closer to a traditional cash benefit programme than to a welfare benefit aligned with the current premises of SW. UBS are also at risk of bypassing those premises. That is the reason behind the claim for a user-led and democratically accountable design (Coote et al., 2019; Coote & Percy, 2020), provided that their design can be fully managed.

The second major element of collision between tools is the limited capacity for public funding (Dryzek, 2008; Jakobsson et al., 2018). Public welfare benefits are financed through a budget in which items directly compete against each other based on political choices and legal limits. Within current fiscal conceptions, considering a balanced budget, an expenditure item cannot increase without decreasing another one or generating a deficit that would ultimately cause a reduction in future budget items. Likewise, as the paradigm is growth and welfare systems and growth are currently mutually reinforcing, a post-growth transition would result in declining public resources in the absence of a corresponding reform beyond growth and debt. Such a reform would deactivate this conflict, but the conceptual one described above would persist.

Recent proposals that account for this second eventuality consider UBI and UBS to be compatible and interrelated (Büchs, 2021). However, they contemplate that the institutional context will determine the success of these initiatives and their interrelation, as the strengths and weaknesses are a matter of design and not inherent to them. According to this novel approach, three institutions are key to fostering complementarity and achieving a beneficial result: governance of both market and collective provision, economic policies, and a design of collective decision-making. Governance would allow the determination of social and environmental standards and the degree of responsiveness

to needs that would cancel a collision between voluntarism and socially meaningful activities. Economic policies would address and control the distributional impacts of the instruments that would ease possible counterproductive reactions of labour supply, employment levels, consumption, and resource intensity. Finally, a collective mechanism for decision-making would provide the democratic accountability that they need to overcome a potential paternalistic bias that would erode unconditionality.

4.5.5. Downscaling Sustainable Welfare tools: A proposal for joint application of CBI+S

The literature has discussed the nature and potentiality of CBI as a derivation of UBI, between this SW tool and PES (Fletcher & Büscher, 2020). Symmetrically, SW could also analyse the potentiality of UBS to be downscaled to local contexts through Conservation Basic Services (CBS) and jointly applied with CBI (CBI+S).

Following the rationale of the original theorisations, CBS would be systems of unconditional provision of services to cover needs as they arise in conservation-critical communities. Attending to the abovementioned criteria (Büchs, 2021), we could repeat the examination of the social-environmental strengths and weaknesses of this potential instrument:

Regarding the satisfaction of human needs, CBS are essentially the same kind of virtual income that UBS represent to pursue free time and meaningful activities (Coote & Percy, 2020; Gough, 2019), this time in specific conservation critical areas, and inherits the potential efficiency and effectiveness of this conception beyond monetarisation (Coote & Percy, 2020). CBS in these areas under restructuring would be especially effective, given the need for alternative activities in non-energy sectors and the level of ageing and dependence in rural areas. Therefore, care would generate the most significant and stable job opportunities under this proposal and grant increased social capacities, as claimed in the previous analysis of these areas (Díez Modino & Pardo Fanjul, 2020).

In terms of natural boundaries, the possibility of designing CBS in the most environmentally friendly manner, far from resource intensity and international competition, unavailable in the case of CBI, would benefit from the decentralised perspective of attending to conservation critical areas. The real needs of citizens are clearer on these small scales and the processes to reveal them are more manageable. Thus, the conception of sustainable services on such a reduced scale would serve to avoid the obstacles of political decision-making attached to the design of UBS and consequently, downgrade the potential paternalism. Here, not only is the scale decentralised, but the power to decide and organise is also shared, due to the small population, individuals' closeness in the community, and the experience of previous collective organisation, as happens with communal woodlands, which are common in northwestern Spain.

Despite this feature to further support livelihoods for a just restructuring beyond growth, the effect of CBS on the demand for energy and transportation in low-income households is uncertain, and probably determined by the characteristics of the precise place where they are applied. In case of negative impacts, the adjustments proposed by Büchs (2021) in the top of the distribution should be adapted to the context: the top of the local distribution would be lower than the top of a macro distribution when UBS are applied to a whole country. A possible distribution from richer and urban areas that have benefitted from the local fossil energy could be a solution (Fletcher & Büscher, 2020).

This adjustment would be necessary for alignment with the criterium of fairness. A trait of basic services is the ability to improve the distribution of the capacity for needs satisfaction (Portes et al., 2017). That distribution is higher as taxes are more progressive in macro approaches (Gough, 2019; Verbist et al., 2010). Yet, in conservation-critical areas, tax systems are not local and besides, the capacity for progressivity is limited. Again, a possible progressive redistribution from urban areas could be useful.

Lastly, as mentioned, CBS would reinforce the democratic governance of basic services by avoiding paternalism through decentralisation. In these small areas, characterised by community spirit, closeness, and historical experiences in collective management, there is a better chance to develop coproduced and democratically accountable services (Coote et al., 2019; Coote & Percy, 2020). In the case of paternalism or non-democratic top-down management by some decision-makers, social pressure would be higher than on macro scales. Therefore, there is an implicit incentive scheme to respect democratic governance for CBS.

Once CBS have revealed the advantages under previous comparable criteria, there is a need to explore a joint application of CBI and CBS (CBI+S), as analogous to "the not so conflicting nature" of UBI and UBS in macro scales, where three theoretical elements are necessary to carry out successful compatibility: governance, economic policies and collective decision-making (Büchs, 2021).

Precisely, the key advantages inherent to local areas to reach a successful joint application of these instruments have already emerged. Governance is reinforced by the decentralised perspective of local areas, which ensures a clearer and simpler determination of needs. This goes hand in hand with collective decision-making, which has historically characterised smaller areas, differently from more individualistic approaches in larger and more dispersed communities, like urban areas. The feeling of belonging in small areas, tradition, and former experiences in collective processes necessary to ensure survival, such as agriculture in communal woodlands in northwestern Spain, generate incentive schemes to apply collective and mutually benefitting decisions. The power to decide is as decentralised as the scale on which SW is applied. Clearer and

simpler needs serve to avoid the obstacles of political decision-making on macro scales, downgrade paternalism, or attempts to denaturalise unconditionality, hence contributing to preserving the nature of SW.

However, the third condition for joint application is not straightforward in these areas: the design and execution of economic policies. As stated, the reaction of household demand is not clear after the application of the proposed SW tools and there will probably be a need to compensate for counterproductive impacts. Yet, if theorisations of SW in macro scales rely on the tax system, this tax system is not specific nor sensitive to local areas. Consequently, this limitation would require greater power of local scales, and greater independence for them to collect public revenues and execute political plans locally. There is an omnipresent claim to increase localism in transitions to sustainability since it is theoretically considered a key driver for the transition (Westholm & Beland Lindahl, 2012), even if we do not observe such a positive effect in the testing of the hypothesis of synergy (Section 4.4).

Parallelly, there would be a requirement to ensure that previously neglected dynamics, such as the environmental ravages caused by fossil exploitation to supply richer distant areas like cities, are compensated. In general, greater relevance to local levels should be made compatible with national or regional taxation systems in which the differences between urban and rural areas result in a more balanced way.

Regarding CBI, some suggestions to solve the above-mentioned doubts and proportionate certainty can be offered based on the available literature:

Considering the recipients, communities located in a conservation-critical space should receive the transfer. However, this is not incompatible with providing income to those users of critical local conservation resources outside the areas whose livelihood is highly dependent on such resources. A similar system already exists in the Spanish CTJ in which residents and dependent users are both suitable to access benefits.

The introduction of compulsory community engagement activities erodes unconditionality and even universality. As seen, the mere declaration of the end in the title of the benefit generates an incentive scheme to orientate actions towards it, but also, it is reasonable to think that inhabitants of conservation critical areas, who have strong personal bonds to such places, are motivated to preserve them. If the belonging to the community is administratively fixed regarding time, five years can be adequate (Standing, 2017; Van Parijs & Vanderborght, 2017) to prevent potential migration and, subsequently further environmental damage, if a pull effect is considered possible and not spurious.

The minimum level of income around one-quarter of the GDP per capita (Van Parijs & Vanderborght, 2017), or at least higher than the minimum threshold for healthy living (Hickel, 2017), is adaptable enough to be applied in a multiplicity of contexts.

Taking 2020 as a reference in constant USD of 2015, Spain should grant a CBI of around USD 6,233 annually (USD 17 per day) (World Bank, 2022) and update the benefit through the application of the inflation rate.

Regarding childhood rights in the frame of universality, the legal age could be applied to align the proposal with current law and as suggested by Fletcher & Büscher (2020), let the main adult acting as the caregiver be the temporary manager of the benefit. Yet, some measures could be applied in the design of the benefit to ensure that the adult preserves the best interest of the children.

Concerning funding mechanisms, beyond approaches relying on voluntarism, like donors, patrons, revenue from products, and crowdsourcing (Büscher & Fletcher, 2020), the main way of funding should be public (Standing, 2017; A. Stern, 2017), in alignment with the public nature of the social-environmental problem of fossil exploitation, phase-out, and transition to sustainability. Numerous externalities, both positive and negative, can be easily observed in this sense.

Finally, the excessive monetarisation of CBI could be compensated in the terms indicated above with a joint application of CBS, which would also serve to establish a quick way of compensation if the environmental effects of SW benefits become counterproductive. For example, by downgrading the CBI in favour of a higher provision of CBS, designed under adjusted social-environmental criteria.

4.6. Conclusions

The hypothesis of synergy states that Social-democratic WS are in a better position to evolve towards ES, particularly pointing to the Nordic countries, and has been notably theorised, but few studies have tested it empirically. Theoretically, the drivers of synergy are decommodification, low social stratification, democracy, powerful local administration, ecological modernisation, structural parallelisms between WS and ES, prioritisation of low-intensity services and the assimilation of environmental and social policies. However, drivers are double-edged swords and could promote both synergy and conflict.

Empirical studies have reached contradictory results and suffer from significant weaknesses, many of them unnoticed due to the absence of methodological discussions. Previous studies did not consider the relevance of the local administration, the parallelisms between WS and ES, or the assimilation of policies, but included variables that are unrelated to the drivers. In addition, we have noticed some inconsistencies, such as the primacy of magnitudes related to GDP despite the requirement of decommodification, the misunderstanding of social stratification and the link between services and dematerialisation, the irrelevance of some political variables, the use of non-comparable data and the shortcomings of the environmental variables.

To cover these gaps, we propose a novel set of strictly social, strictly environmental and intermediate variables. To obtain comparable results, we apply Ward's hierarchical clustering and Thorndike's criterium to avoid the previous assumptions about the number and typology of clusters. Due to shortages in data availability, we must drop non-European countries as well as some variables, such as an updated generosity index and the Palma ratio, and stick to their second-best options, such as welfare effort and income shares.

Our sample overlaps between 2008 and 2016 and aligns with previous research, which covers discrete years, such as 2010 and 2016. To avoid biases derived from discrete analysis, we observe clusters throughout the period and present the results in the form of concurrence scores between countries. Given the interest in generosity, we repeat the clustering by including the generosity index for the countries and the period in which it is calculated (2007–2010), without causing significant variation.

Concurrences prove that clusters are unstable, therefore reinforcing the need for dynamic observation, notably in times of crisis, when countries experience differential evolutions. The Nordic countries, which do not constitute a single group but two, are the most exclusive and stable.

By comparing the relative positions of variables for each concurrence, we have rejected the hypothesis. The Social-democratic regimes present the best social and the worst environmental performances. The Nordic countries are unable to translate the mobilisation of domestic resources and energy renewability into decarbonised and dematerialised economies and present the biggest carbon and material footprints. Results are not aligned with Esping-Andersen's typologies or its variations.

Provided that synergy seems empirically unavailable, it should be observed as a possible normative purpose to achieve in the framework of a just transition. Methodologically, there is a need to surpass classifications of regimes and determine the conditions for synergy, thus pointing to dynamic simulation techniques to enrich a debate that could be set out in terms of social-environmental feasibility rather than comparison. Ultimately, synergy involves a discussion about the sustainability of economic growth that could benefit from the emerging field of SW to study the loose ends formulated in this work, with a special focus on UBS supported by the institutional configuration of WS.

To contribute to addressing the concerns commented in local rural areas, this Chapter also carries out a commentary on the potentiality and essential matters of UBS in contrast with UBI. Subsequently, it carries out a downscaling of these SW instruments, mostly conceived at a national scale, to adapt them to the local rural areas, so they could be applicable in cases such as the areas under restructuring in León. The final suggestion

is a combination of incomes and services for conservation critical areas, where some facilitating institutions are present.

As we have fulfilled the structure and goals of the research, the main conclusions of the thesis are presented in the next Chapter.

Chapter 5

CONCLUSIONS

Societies are currently going through a twofold crisis globally, environmental on the side of resources (peak oil) and residues (climate change), and social. While humanity surpassed critical ecological limits more than a decade ago, poverty, inequality and discrimination are widespread and aggravated by the financial crisis in 2008 and the pandemic in 2020.

To tackle the double crisis, governments are incentivising socio-ecological transitions to sustainability. In the panoply of fronts for a sustainable future, the energy transition holds a relevant place given the intensity of energy use, the level of pollution that is related to such energy use, and the deep relations between energy, environment, and society. The energy transition is no longer considered a mere shift in energy sources, but a set of profound rearrangements that requires changes in the socioeconomics of a context and causes impacts of a diverse nature.

In the convergence of social and environmental matters, the notion of just energy transition emerges. However, it is not a new idea in the study of the social-environmental conjunction, but a revival of the unionist claims in the North American energy sector in the 1970s. It has been re-examined following the SDGs, adapted to the current context, and spread, both regarding the geographical scope and the underlying streams of thought. As we show in our bibliometric approximation, the concept has transcended its original scope to nurture scholarly discussions, notably since 2015.

This (re)emergence has motivated this research work. From a scholarly perspective, there is a need to contribute to the theoretical framing of the idea and the study of the effects on labour and income distribution, by translating the abstract concept of justice into real practice. Concurrently, there is a need to orientate political agendas with scientific insights beyond political conditions through Environmental Social Sciences.

At the present moment, the primary method to study justice in energy transitions is the elaboration and execution of models. Models are frequently classified into categorical classifications (numerical vs. analytical, top-down vs. bottom-up, economic complexity vs. ecological complexity, inter alia) that have been left aside by the state-of-the-art, more prone to combinations. Growing interest is receiving systemic modelling to encompass multidimensional and transdisciplinary approaches, required by the nature of

the topic. Notwithstanding, analysis of indicators are also common. Moderate interest in polls has also been found to determine the perceptions of justice among citizens, a relevant issue that directly involves the procedural dimensions of justice and is hardly ever introduced in analyses.

Nevertheless, we have detected gaps in the state-of-the-art that have inspired the proposal of a research agenda on three fronts: conceptual, thematic, and methodological. Conceptually, there is a need to introduce controlled degrowth and consider the gender dimension of the process. Thematically, there is a margin to increase the number and typology of case studies, deepen the knowledge about the impacts on income, and diversify the analyses about labour. Methodologically, we suggest exploring systemic and dynamic modelling tools, reinforcing the macro level of national models, and considering subjective perceptions.

The analysis of just energy transitions is particularly relevant in our closer context. Fossil-dependent areas in developed countries under intense deindustrialisation during the past decades have the potential to illustrate the process and offer additional insights. Notably relevant is the case of León, in Spain. The Leonese economy progressed based on coal mining and thermoelectric generation since the 18th century. The railway, World War I, protectionism, and the oil crises contributed to the peak of this coal economy by the 1980s. Subsequently, it initiated a sharp decline due to the competition with the entry of Spain into the EU, the climate agreements, the increasingly cheaper RES, and the rise of the cost of GHG emissions. The decline has caused a significant socioeconomic deterioration that has aggravated locally the generalised processes of migration, depopulation, ageing, dependency, and territorial polarisation.

The beginning of this research work coincided with the introduction of the Institute of Just Transition and the Agreements (CTJ), launched by the Spanish MITECO to dynamise fossil-dependent declining areas through local resources. León concentrates most of the actions on a regional scale and represents a case of strategic relevance at a national scale to determine the effectiveness of the political plans under the precise framework of just energy transitions. Leonese areas present notable strategical advantages for a just energy transition, such as a convenient climate and orography to promote PV, and remarkably wind, hydro, and biomass power; technological capacity for the manufacturing and installation of RES; and a labour force that is educated in technical skills because of the historical specialisation in mining, supported by a network of universities, schools, and vocational training centres.

Following our suggestions in the research agenda, the Leonese case contributes to widening the variety of methods applied to study the effects of the transition on labour, varying the typology of cases and geographic units, considering the framework,

particularly the developments of the ILO, and exploring the possibilities of systemic thinking.

We have detected negative effects of the transition to RES both in the revision of literature and in our exercises of simulation. In our revision, even if impacts are widely positive but limited on labour, there is a relevant share of papers that obtain negative and mixed impacts, such as the difficult restructuring of some sectors or the low labour mobility of senior workers. Moreover, there is a bias towards quantification, hence eluding the quality of such jobs, about which few insights are available in the literature and reports. Regarding the distribution of income, studies find broad and relevant negative effects, primarily related to a rise in energy prices and regressivity, hence igniting social conflicts and causing poverty. In the simulation of the Leonese case, we have found that considerable potentiation of RES, even in the most optimistic scenario, is far from providing a just transition. In our simulation, although greater detail is offered below, the model illustrates relevant challenges that disable a proper just transition in León.

As studies confirm the negative impacts of the energy transition, in different degrees depending on the context and energy strategy, there is a growing claim for greater public intervention through WS to ease the process. In this regard, we have detected a need to delimit the manners in which governments can compensate for the negative impacts and potentiate the positive outcomes in wide institutional contexts.

Consequently, the hypothesis of eco-social synergy holds a relevant place in this discussion. It states that Social-democratic WS in the sense of Esping-Andersen's secular classification, those with a high decommodification and low social stratification, are in an advantageous place to perform a transition to an Environmental State, the ES, hence supporting the just energy transition. Despite the vast development of the hypothesis in a theoretical sphere, empirical efforts have been more limited and presented methodological weaknesses and contradicting results.

To contribute to clarifying the possibilities of action via current welfare mechanisms and orientate political agendas, we have performed an empirical contribution to further the knowledge about the potential eco-social synergy. In this attempt, we have introduced methodological improvements to prevent the most determining weaknesses observed in previous works. We have introduced omitted drivers, such as the relevance of the local administration, the parallelisms between WS and ES, and the assimilation of environmental and social policies. We have excluded variables that are unrelated to the literature or present a subjective nature, contrary to the objective formulation of the hypothesis. Additionally, we have refined the selection of indicators in previous studies by introducing welfare generosity to avoid GDP where possible, 80/20 shares and Palma

ratios, and carbon and material footprints. In our procedures, we have avoided assumptions about the number and typology of clusters by allowing data to freely reflect the behaviour of our sample of European countries from 2008 to 2016.

Our results point to some relevant fronts, particularly the potential introduction of a sustainable welfare regime, SW. We have finally explored the lights and shadows of SW and downscale its primary tools to the local rural scale, to streamline the process of transition in the scale observed in the Leonese case.

In this research itinerary, from the notion under study to the simulation of effects at a local scale and the welfare proposal to satisfy our goals, we have relied on a triple theoretical framework, constituted by the lessons of Ecological Economics, the historical and empirical unfolding of just energy transitions, and the structures of the current WS and their adaptation to ES.

Ecological Economics conciliates the environmental and socioeconomic spheres and motivates our transversal focus on the process of transition to facilitate a sustainable socio-ecological regime, the interest in sustainable human welfare, a vision beyond growth and inside ecological limits, incommensurability, and a notion of spatial analysis.

Just energy transitions, as a field of study, bring to this thesis the historical background of past energy transitions and social-environmental claims, diverse normative approaches, particularly focusing on the developments of the ILO.

The theory of WS used as a substratum for the orientation of political agendas revolves around the taxonomy of welfare regimes, their traits, differential evolutions, possible retrenchment, and relation with the environment.

This triple theoretical framework has also motivated a triple methodological strategy. We rely on an unweighted systematic review of the available literature about the socioeconomic effects of transitions to RES, a dynamic simulation inspired by SD to picture the most relevant dynamics of the rural area under data shortages, and the application of Ward's hierarchical clustering algorithms and Thorndike's criterium of optimality to study synergy.

We have formulated two hypotheses that we solve as follows:

Hypothesis 1

The energy transition is considered an opportunity to provide jobs. The proliferation of RES requires economic activities such as construction, installation, manufacturing, operation, and maintenance to the extent of seeing RES as more labour-intensive sources than traditional ones.

As the energy transition progress, considering the framework theorised by the ILO (Figure 1-7), we ought to expect a displacement of investments from conventional to green sectors, a subsequent labour-demanding deployment of infrastructures, an injection of subsidies to fund these technologies, as well as education programmes to facilitate the transition. In consequence, the demand for workers is expected to increase in the energy sector. A positive impact in the energy sector is likely to increase disposable income and arouse a sensation of economic security among workers, with a subsequent positive impact on the rest of the economy. Meanwhile, negotiation would serve to improve the quality of jobs, including the level of wages. As income increases, the revenues that the public sector can collect also grow so that governments can tackle inequalities and poverty with greater supporting resources under the form of defensive policies.

Provided that the transition to RES is expected to have a positive impact, it is considered a relevant opportunity for declining fossil-dependent areas in developed countries under intense processes of deindustrialisation, which have experienced a sharp socioeconomic erosion during the past decades. Although some alternatives have been formulated for them in diverse contexts, the most immediate option is a reconversion towards RES. This option is adequate, given that the needed energy infrastructures to transport energy are still in place and human capital is highly specialised in technical skills because of past experiences in mining and thermoelectric production.

Coherently with this vision, we hypothesise that *the impact of the energy transition on employment and income is positive for the energy sector (direct) and this positive result echoes in the rest of the economy (indirect and induced).*

Result: Positive but small impacts on employment levels, particularly reinforcing for green energy sectors, construction, and manufacturing. Negative impacts on income and its distribution. In the local areas under study, RES compensate for the fossil jobs at risk. Nonetheless, these technologies are unable to provide relevant shares of occupation and incur trade-offs between employment creation and land uses. Alternative activities are required to compensate for socioeconomic deterioration.

Most of the studies (62%) concerning the socioeconomic impact of the energy transition, whether affiliated to the precise framework of just energy transitions or not, converge to point to a positive, yet significantly small, effect on employment levels. 11% of works conclude an unambiguously negative impact, while 27% detect mixed effects. This outcome is more pessimistic than expected at the beginning of the research, providing the emphasis made by political strategies on greening activities to improve employment levels and the higher labour intensity of RES, in contrast with conventional sources.

The revised studies were published before the COVID pandemic, as the literature review and related research activities were executed in the last quarter of 2018, 2019, and the first quarter of 2020. However, there are pieces of evidence that clarify that the conclusions that have been obtained from them are still valid.

At a European level, small positive impacts are linked with an increase in green investments, particularly regarding energy, construction, and the processing of materials in a context of fast-paced transition. Some problems arise at this scale and are related to the low labour mobility of aged workers and the appearance of shortages of skilled workers, although of lesser relevance in other papers, probably because of their methodological background. Moreover, the proliferation of battery electric vehicles is a source of negative impacts.

In a national and regional context, Germany serves to illustrate the negative results of its strategy, particularly in the transition of electricity. It is also useful to detect the importance of the speed of policy implementation as a determining factor, as well as the external economic sector. The national results are distributed unequally between regions. From a sectoral viewpoint, energy, construction and manufacturing are the sectors leading the positive impacts, while the rest of the economy undergoes a negative impact, mainly as a result of rising electricity prices attached to the deployment of renewable infrastructures. Nonetheless, the propagation of effects on the economy is dependent on the level of investment and the degree of market flexibility.

The national cases of the Netherlands, Italy, and France reinforce previous conclusions. In the French case, D'Alessandro et al. (2020) offer information about the social and environmental implications of green growth and degrowth, being degrowth the option that contributes the most to the improvement of the social-environmental situation.

The studies about employment have experienced relevant methodological improvements in recent years, such as widening their scope beyond the sole impact of green taxes and focusing on net impacts. However, studies do not dive into the impacts on the quality of jobs, the working hours, and gender. Consequently, when we detect a positive impact on employment, we are referring to employment levels. Future works should disclose the implications of the transition on the quality of jobs, the distribution and variation of working time, and the precise consequences for women.

88% of the revised works find unambiguously negative effects of the transition on income. This result mostly refers to the distribution of income, instead of its level.

The progress of the energy transition is associated with the rise of energy prices, to fund the deployment of infrastructures, hence reinforcing energy poverty and social conflicts. However, there are discordant conclusions regarding this causal chain, and works that assume that higher prices are the market logic for higher energy qualities, thus

not problematic. In the US, there is not a negative impact on the population overall, but for precise groups of individuals, such as the young workers, with a low skill level, low labour force participation, and located in rural areas. Rural areas seem especially challenging in distributive terms due to the higher burden that represents the deployment of grids in remote and/or dispersed locations.

Apart from the interaction between income and energy prices, a second impact is found concerning the fiscal regressivity of RES subsidies. Even if the regressivity of taxes is a more frequent topic of study, there are increasing pieces of evidence that suggest that energy subsidies tend to be proportionally more beneficial for wealthier individuals.

A relevant insight is the role of perceptions, as the public opinion is demonstrated to notice higher burdens than those registered by objective indicators, being perceptions correlated with sociodemographic circumstances. Whether these perceptions are dispensed by lobbyist practices or not, the procedural dimension of justice recommends us to consider the subjective sphere of opinion.

Regarding scenarios, the EUROGREEN model, executed for the French case, pictures widening inequalities as a result of green growth strategies. In contrast, green growth reinforced by the application of social policies and degrowth achieves better distributive results at the expense of neglecting the current fiscal paradigms in the EU.

According to literature, outcomes are determined by factors responding to structural and institutional features, such as productive possibilities, demand behaviour, infrastructures, wage levels and elasticities, labour flexibility and intensity, trade patterns, international and administrative cooperation, geographical and historical differences between territories, education systems and knowledge stocks, and even the quality of democracy.

Some of these factors are of a clear institutional nature, to the extent of dedicating a Section of the revision to institutional barriers (Section 2.4.3). Indirectly, some of the remaining factors display institutional conditionings in their determination. Demand behaviour is partly determined by the process of human choice, in which values and traditions play a role. Labour flexibility and the level of wages are the results of collective bargaining in multiple contexts, particularly in the region in which this thesis focuses.

Beyond the literature review, in our case study and given the lack of concretions about precise measures to perform the just energy transition in León, we propose the simulation of four ceteris paribus incremental scenarios to detect the intertwines between employment in local communities, energy, and land.

Consequently, we detect that the preferential installation of the current renewable tenders at a province level would result positive, by compensating in any scenario the

present jobs at risk by 2023 in El Bierzo-Laciana and 2022 in Montaña Central-La Robla. However, a potential compensation in terms of volume is not enough in absence of reskilling and upskilling programmes to ease the mobility from jobs in conventional sources to jobs in RES.

Notwithstanding, regarding the dynamisation of local communities because of the deployment of RES, the conclusions are less optimistic. A compensation of jobs at risk, at the moment of closure, does not provide the historical levels of occupation that the areas met during the expansion of fossil exploitations. Likewise, under BAU employment factors, the new graduates in local education centres progress at a higher pace than the hirings linked with the deployment of RES. Employment factors in León are notably below the average national factors found in the literature. Hence, a subsequent simulation in which factors tend to such an average, considered the most optimistic scenario, has revealed negative outcomes, different for each area. In the more dynamic area of El Bierzo-Laciana, this situation absorbs new graduates and fails to include experienced workers, or benefits experienced workers while neglecting the novice. In the less dynamic area of Montaña Central-La Robla, it provokes a shortage of qualified workers by 2029.

In consequence, alternative activities to RES, such as rural tourism, the agroindustry, and the "silver economy", mentioned in the CTJ, are indispensable to keeping the population, yet equally limited in terms of occupation.

As we parallelly perform estimation in terms of required land, we have detected that relevant areas can be compromised as a result of RES, particularly solar PV. Besides, significant trade-offs arise between employment levels and demand for land, as well as fragile balances in the distribution of spatial and social impacts between the two Leonese areas under transition. Hence, RES can boost social conflicts and environmental ravages, subsequently hindering the cited alternative activities.

Apart from offering an exercise of simulation, we have revised the current political plans for León that are launched by the Spanish MITECO through the CTJ. CTJ demonstrate significant limitations in contrast with the framework of just energy transition. These shortcomings could serve to correct the ongoing processes and prevent their inclusion in future political processes, in Spain and other contexts. We classify these limitations according to their nature, as related to concept and design, diagnosis, and procedural justice.

As far as concept and design are concerned:

- CTJ focus on the quantification of jobs, even if labour income has been considered after the phase of external audit. The quantification of jobs covers both own and outsourced workers, which is a recommendable practice to maximise the social protection of the plans. However, the

quantification is established at the moment of closure of the fossil facility, when the situation is in terminal decline, after three decades of deterioration. CTJ contemplate the loss of 1,014, or 960 after the revision, while they recognise the existence of up to 45,212 workers in fossil activities in 1990. It may be questioned if the criterium of quantification at closure is suitable in presence of historical destructions of jobs.

During the audit, two additional criteria were included to account for the presence of workers in 2001 and 2011, with a scarce effect in this regard, given the unfolding of the previous two decades of socioeconomic deterioration.

- Apart from the level, the quantification detects direct effects, but does not consider indirect and induced effects, which are considerable given the socioeconomic status in Table 3-1. This limitation also causes a restriction in the simulative capacity of our model, which inherits the direct focus, despite the need for further detail in the propagation of impacts on the economy. Additionally, in CTJ direct impacts are referenced to the working-age population, instead of the active population, due to a lack of data at a small municipal scale. This choice can uncover phenomena affecting the active population, such as the presence of "discouraged workers".

- The focus on quantification annuls the analysis about the quality of such jobs, in contrast with the theorisations of the ILO. The sole mechanism to contribute to promoting quality jobs is the Tripartite Dialogue, which does not provide any strategy to foster adequate positions. As stated by the ILO, poor-quality jobs are socially and environmentally damaging outcomes of the transition. Even if the impact on employment levels could result positive, the creation or reconfiguration of jobs towards poor-quality positions is a negative impact and an unjust result.

- CTJ correctly contemplate the gender dimension of the transition and recognise women as specially affected by the restructuring. The Women Institute and the local associations of women act theoretically in the processes of energy transition as consultive agents. This recognition is misaligned with the criterium of impact at the moment of closure, provided that only a transition that generates opportunities for women, apart from compensating masculinised activities, is considered just according to CTJ. In the current version of CTJ, there are no precise indications about the contributions of associations of women in the transition.

- The environmental impact associated with the shift in employment is not considered in the CTJ, even if they recognise environmental ravages because of the abandonment of facilities as a threat and a source of opportunities derived from their restoration.
- Remaining criteria also prove problematic:
    - The criterium of coverage to 85% of affected workers supposes an inclusion of municipalities below the average impact until the consecution of the threshold, simultaneously to the exclusion of municipalities with similar impacts to those included.
    - The respect for the territorial scope prescribes the exclusion of affected municipalities in case of not belonging to the autonomous community of reference, despite the processes of just transition being a national initiative.
    - Territorial coherence provides coverage to municipalities with a lower impact than those included. This problem has been minimised in the Leonese CTJ thanks to a narrow margin that activates the criterium of territorial coherence.

Regarding diagnosis, notable limitations emerge from the selection of indicators and the SWOT analysis:

- Sociodemographic and income variables:
    - Information about the level of education is obtained from the census in 2011, as the only available source. Consequently, they omit the evolution during a decade that has resulted decisive in the consolidation of the socioeconomic decline and cannot reflect the COVID pandemic.
    - CTJ take the average labour income of municipalities as a supporting criterium of impact after the audit. Nevertheless, such data are unavailable for smaller municipalities, which constitute most of the area under transition. Accordingly, the delimitation is biased due to the higher level of income in bigger municipalities, where data are available and provided by the INE, as one of the most important sources of CTJ. Moreover, income is expressed in current monetary units, thus including the effects of the variation of prices.
- The SWOT analyses lack specificity and present redundant statements. The SWOT analyses have been reused from former diagnoses at an

autonomous community level and present a coincidence of statements that cannot be explained based on the similarities of the areas under transition. Moreover, this thesis detects a redundancy of statements that deepens the lack of specificity or points to an unnecessary disaggregation of regions in the CTJ. After the audit, coincidences resulted attenuated, particularly with the inclusion of additional area-specific elements, but, contrary to intuition, redundancy increased. Coincidence and redundancy characterise limited and dispersed proposals for a just transition in León and appear jointly with unjustified changes during the audit and asymmetric mentions of common problems. We suspect a dysfunctional application of the SWOT methodology.

Finally, procedural weaknesses are related to matters that have been neglected, apart from the gender issues above:

- The displacement of farmers because of the increasing land rents that the profitable deployment of RES has the potential to cause.
- The implications of RES for the management of the communal woodlands.
- The environmental and landscape ravages of the installation of renewable technologies.

Hypothesis 2

In the process of transition, WS are increasingly seen as necessary to compensate for the potential negative effects and boost positive impacts, hence reinforcing justice. Social-democratic regimes, i.e., those with high decommodification and low stratification, are thought to be in an advantageous position to perform a just transition. On the one hand, decommodification alleviates environmental pressure by providing independence from markets, so that individuals can have a prosperous life without incurring environmentally damaging activities. On the other hand, a low stratification enables individuals to share power and increase democratic practices, so that procedural justice is regarded.

Therefore, we propose the hypothesis of eco-social synergy as our second statement to test: *Social-democratic welfare regimes display better environmental performance and are closer to the notion of ES, hence reinforcing the just transition*.

Result: Social-democratic regimes show the best social situations and the worst environmental performances in our sample. Liberal and Conservative regimes combine better environmental performances with worse social situations. Nonetheless, we suggest dealing with concurrences due to the instability of clusters, particularly in times of crisis, and the diversity of profiles. There is not an unambiguous connection between society

and the environment. The behaviour of Social-democratic regimes is linked with the environmental footprint of consumption, also incentivised by the WS. The environmental impact is determinant in the case of public construction and infrastructures. Hence, although synergy is not currently available, there is a margin to foster it as a normative goal in the transition through SW, also at a local level.

The Nordic countries register the greatest carbon and material footprints despite an above-average share of energy renewability and average recycling rates of municipal waste. Likewise, they present the most decentralised administration, hence favouring the power of the local level, but this decentralisation does not correspond with the potentiation of local environmental resources. Besides, they register the lowest relative environmental spending and the highest potential fiscal competition for funding.

Other countries in the range of Social-democratic regimes, display similar behaviours. This is the case of Austria and the Netherlands, which moderate the competition for funding and the level of decentralisation. The Netherlands obtains comparatively negative environmental results through below-average renewability, but the greatest environmental expenditure and the second biggest recycling rate. Other countries in this range obtain more nuanced results, although negative, as happens with the French-Belgium concurrence, whose role in this respect is defined by Belgium.

Beyond the particularities found in other concurrences, this behaviour contrasts with the Liberal regimes of the British-Irish concurrence and the unexpected concurrence between Germany, Poland and Hungary. Liberals combine average and slightly above-average social performances, very low renewability and average recycling to obtain the lowest footprints, particularly concerning materials. The Eastern-Conservative concurrence is the average social performer, while it registers the second lowest carbon footprint and the smallest material footprint.

These results, which ensure consistency despite the economic cycle because of methodological procedures, point to a variety of social-environmental conjunctions in which social and environmental performances are unrelated. This outcome supports a cautionary approach to the validity of the hypothesis, as formulated in the present state-of-the-art, in Europe from 2008 to 2016.

Our analysis proves that there is not an unambiguous approach, but diverse profiles that support the use of these eco-social concurrences instead of the former categorical WS classifications.

The typologies of WS proposed by Esping-Andersen or the adaptation that is adopted for comparative purposes in this thesis do not correspond with the same environmental performances through our methodology, which determines the clusters optimally, as indicated strictly by data. Moreover, WS regimes appear in different clusters

along the clustering period and in our consolidated results for the period. Switzerland (Conservative) joins Norway and Iceland (Social-democratic), Belgium (Social-democratic) appears with France (Conservative), Portugal (Mediterranean) with Italy (Conservative), and Germany (Conservative) with Poland and Hungary (Eastern).

Our interpretation discloses that the classifications of WS are exclusively related to the social dimension and do not match the obtained eco-social typologies and the underlying performances of the environmental dimension or the behaviour of intermediate variables.

Some of them, such as the Netherlands, Austria (Social-democratic), and Estonia (Eastern), are even unable to form persistent concurrences and result unspecific.

However, we formulate two precautions.

First, we have rejected *Hypothesis 2* in the European context from 2008 to 2016, under our methodology. We consider that we have contributed to surpassing some of the weaknesses in previous analyses, such as the selection of problematic indicators, the omission of relevant variables, and the execution of discrete studies. Nonetheless, we consider that future approaches could still refine the method and propose new procedures to tackle the theoretical formulations of synergy from empirical grounds. Likewise, other contexts and timings, different from ours, could point to differing conclusions.

Second, our results do not deny the potential capability of Social-democratic regimes to foster an eco-social synergy. Conversely, we find some traits that could inspire some reforms that would theoretically contribute to providing synergy. This is the particular case of UBS under the premises of SW.

Further developments and adaptations of current welfare paradigms towards SW could contribute to providing synergy, theoretically, both at global, national, and local scales. Local scales have been again relegated in the proposal of SW. As a response, we propose a joint application of CBI and CBS: CBI+S.

This thesis has dived into just transitions and found outcomes that contradict political ambitions and are far from scholarly insights. However, several opportunities have emerged to contribute to the study of the topic and promote fair sustainable futures. We conclude this Chapter and thesis by highlighting the proposal of the research agenda, the detection of key dynamics and strategical advantages in the Leonese case, the methodological discussion to test eco-social synergy, the reinforced knowledge about the functioning of the WS-ES conjunction and the formulations of SW, with a subsequent derivation for local scales.

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