Universitat Autònoma de Barcelona

Imaginaries of innovation and science: critical analysis and sustainability concerns

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Ph.D. Dissertation

Doctoral Programme in Enviromental Science and Technology

Institut de Ciència i Tecnologia Ambientals (ICTA)

Universitat Autònoma de Barcelona (UAB)

February 2022

Abstract

The motivation of this dissertation arose from the need to investigate certain political processes that are articulated in two intertwined spheres: (i) innovation-based European policies in the institutional sphere and (ii) narratives that (re)invoke idealised visions of science in environmental issues in the public sphere. These processes are also articulated in a situation of the widespread legitimacy crisis of our scientific and governance institutions.

In the institutional sphere, we ask if (and in which ways) the innovation-based European policies could be (re-)acquiring meaning when interacting with critical perspectives that highlight difficult nexus tradeoffs and socially inflicted harm. Specifically, we aim to investigate the role played by innovation (as imaginary) in this European policy meaning-making in a legitimacy crisis of the European project. To address this research question, we critically and didactically analyse two innovation-based European political strategies—the EU2020 strategy and the circular economy. Specifically, in the first case study and from a Foucauldian perspective, we critically analyse (i) the role of innovation (as imaginary) in nexus governance and in shaping the idealised EU2020 discourse on "sustainable growth" and (ii) the implications of the discourse for nexus governance and some social issues. In the second case study, we develop a better understanding of the role of innovation (as imaginary) in (and for) nexus governance in the circular economy policy, through two theoretical lenses that reflect on problems and nexus tradeoffs at the environmental governance system level. Both critical analyses allow us to develop a better understanding of the role of innovation (as imaginary) when interacting with the critical perspectives we applied, so that these relations might enable European policies to be (re-)shaped.

In the public sphere, we (i) investigate possible roles of idealised visions of science on environmental issues that are (re)invoked in narratives articulated in a generalised crisis of legitimacy, and (ii) reflect on how these narratives interact with critical perspectives that advocate an acknowledgment of the complexity and uncertainty. To address this research question, we critically analyse the polarised narratives that promote idealised visions of science in the climate change issue in the social media web "I fucking love science" and emerge in reaction to a morbid symptom of the legitimacy crisis: Donald Trump's election as president of the USA in 2016. Specifically, we apply two critical perspectives (which advocate a recognition of the complexity and the condition of high uncertainty) toward the most predominant narrative conceptualised in the social media web, and we reflect on how this narrative interacts with the critical perspectives applied.

Through this dissertation, we roll out a set of paradoxes and learning lessons for debates, fundamentally, on sustainability and environmental governance.

Resumen

La motivación de esta disertación surge de la necesidad de investigar determinados procesos políticos que se articulan en dos esferas entrelazadas: políticas europeas basadas en la innovación en la esfera institucional y narrativas que (re)invocan visiones idealizadas de la ciencia en cuestiones medioambientales en la esfera pública. Dichos procesos se articulan en una situación de crisis generalizada de legitimidad de las instituciones científicas y de gobernanza.

En la esfera institucional, planteamos si las políticas europeas basadas en la innovación podrían estar (re-)adquiriendo significado al interaccionar con las perspectivas críticas que destacan tradeoffs del nexus y daños infligidos socialmente. Concretamente, queremos investigar el papel de la innovación (como imaginario) en este proceso de construcción de significado de las políticas en una situación crisis de legitimidad del proyecto europeo. Para ello, analizamos críticamente y didácticamente dos estrategias políticas europeas –la estrategia EU2020 y la economía circular. Específicamente, en el primer estudio de caso y desde un enfoque foucaultiano, analizamos críticamente (i) el papel de la innovación (como imaginario) en la gobernanza del nexus y en la formulación del discurso de la estrategia EU2020 sobre el "crecimiento sostenible", *y* (ii) las implicaciones del discurso *para* la gobernanza del nexus y algunas cuestiones sociales. En el segundo estudio de caso, desarrollamos una mejor comprensión del papel de la innovación (como imaginario) en (y para) la gobernanza del nexus en la política de la economía circular, a través de dos lentes teóricas que reflexionan sobre los problemas y tradeoffs del nexus a nivel de sistema de gobernanza medioambiental. Ambos ejercicios críticos nos permiten entender mejor el papel de la innovación (como imaginario) al interaccionar con las perspectivas críticas aplicadas, de manera que estas relaciones podrían permitir la (re-)formulación de las políticas europeas.

En la esfera pública, investigamos (i) posibles roles de visiones idealizadas de la ciencia en cuestiones medioambientales que se (re)invocan en narrativas articuladas en una crisis generalizada de legitimidad y (ii) reflexionamos cómo estas narrativas interactúan con perspectivas críticas que abogan por un reconocimiento de la complejidad y la incertidumbre. Para ello, analizamos críticamente las narrativas polarizadas que promueven visiones idealizadas de la ciencia en la cuestión del cambio climático en la web social "I fucking love science", y emergen en reacción a un mórbido síntoma de la crisis de legitimidad: la elección de Donald Trump como presidente de Estados Unidos en 2016. Específicamente, aplicamos dos perspectivas críticas (que apuntan hacia un reconocimiento de la complejidad y la condición de alta incertidumbre) hacia la narrativa más predominante conceptualizada en la web social, y reflexionamos como interactúa dicha narrativa con las perspectivas críticas aplicadas.

A través de esta disertación, desplegamos un conjunto de paradojas y lecciones de aprendizaje para los debates, fundamentalmente, sobre la sostenibilidad y la gobernanza medioambiental.

Acknowledgements

This dissertation has been a long journey, not without difficulties and challenges. I would like to thank many people that have supported and inspired me to make it possible.

I am incredibly grateful to Roger Strand for his genuine and wise supervision throughout the dissertation, for allowing me a space of intellectual freedom and creativity and for providing invaluable advice and knowledge when necessary. I would also like to thank him for his unconditional friendship and help at the most difficult of times, for the great patience he has shown me and for always believing that this thesis was possible.

I would like to thank Louis Lemkow for helping this dissertation to come about. I also thank the Institut de Ciencia i Tecnologia Ambientals, at the Universitat Autonoma de Barcelona (Spain), for facilitating this research.

I am most grateful to the Centre for the Study of the Sciences and the Humanities (SVT) at the University of Bergen (Norway) for financing part of the research work and hosting me during my two research stays with a warm welcome. The SVT has greatly inspired and influenced me, and I appreciate all the valuable feedback received. I am thankful to Tone, Matthias, Judith, Ragnar, Idunn, Ingrid, Sissel, Helene, Dafne, Henrik, Rasmus, Jan Reinert, Kjetil, Silvio, Andrea, Scott, Jeroen, Gunnar, Torjus, Thorvald, Dorothy, Anne and Laura.

I am extremely grateful to Zora Kovacic for the great feedback and constructive advice throughout the dissertation. I am also indebted to Idun Strange for her valuable comments during the initial phase of the research, to Azahara Romano for her support and comments at the final stage of the thesis and to Kim Eddy for learning with her a little more about how to write in English.

I thank the Altona Foundation for Philosophical Research for the invitation to participate in the Post-Normal Workshop, as well as the feedback received through the S.Net Conference and the third Post-Normal Science Conference.

A special thank you to Rubí for helping me learn how to navigate life and take care of myself. I also thank Elisa for always believing in me and Reidun for making the research stays in Bergen shine even brighter. I would like to thank my grandmother for being a great example of resilience, mother for her infinite and unconditional support, my nephews for their wonderful laughter, my siblings Verónica and Diego for the strength they teach me, and my father—he would have been very proud of me. I also thank all my friends for their encouragement on this journey.

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Capítulo 1[2]

Introducción

1. Motivación

1.1 La crisis y lo nuevo que no puede nacer

La palabra crisis se ha ido convirtiendo en una palabra recurrente en nuestro discurso cotidiano, al menos, desde el alcance extendido de la crisis financiera de 2007-2008. En nuestro país de origen (España), dicha crisis tuvo severas consecuencias, particularmente en términos de oportunidades sociales y económicas para los ciudadanos (Escribà-Agüir y Fons-Martinez, 2014; De Arriba, 2014). Dichas consecuencias también ocurrieron mayoritariamente a nivel europeo, especialmente en países como Italia, Grecia y Portugal (Barroso, 2017). Desde las perspectivas críticas de la ciencia post-normal, el desarrollo de la crisis financiera a gran escala no sería entendido simplemente como una cuestión basada en la mala fe de los políticos al guiarse por intereses económicos, o de expertos que hicieron mal su trabajo en el campo científico-económico y luego asesoran a los políticos. Las condiciones sociales, políticas, económicas, históricas y culturales que permitieron a la crisis desarrollarse globalmente, estarían relacionadas con una estrategia moderna de legitimación que se ha manifestado inadecuada para tratar cuestiones caracterizadas por condiciones de complejidad y alta incertidumbre (Funtowicz y Ravetz, 1993, 1994). En otras palabras, el alcance extendido de la crisis financiera pondría de manifiesto una crisis más profunda en el sistema de legitimación que se haya enraizado en el funcionamiento de nuestras instituciones científicas y de gobernanza (Funtowicz et al., 2016) (Funtowicz y Saltelli, 2017) (Kovacic 2013).

Sin embargo, desde estas perspectivas, nuestros gobiernos e instituciones parecen no reconocer la profundidad de dicha crisis, ya que acentúan creencias idealizadas que son centrales en la estrategia moderna de legitimación (ej. ciencia produce un conocimiento "neutral y objetivo" y es una fuente ilimitada de progreso económico e innovación tecnológica, Funtowicz y Strand, 2007). Por ejemplo, el principal marco político para dar respuesta a la crisis financiera de 2007-2008 a nivel europeo – la estrategia EU2020 – proclamaba un crecimiento inteligente, sostenible e inclusive vía *innovación* tecnocientífica (European Commission, 2010a). Concretamente, la innovación se promovía como una prometedora "solución" para aliviar no sólo los problemas económicos y sociales sino también los medioambientales, a pesar de los crecientes debates sobre

[2] Este capítulo introductorio se ha redactado en español y el resto de capítulos en inglés. Dado el predominio de este último idioma en el conjunto de la investigación y dado que muchas de las fuentes bibliográficas citadas en este capítulo se citan en otros capítulos, hemos configurado nuestra lista final de referencias bibliográficas con referencia al idioma del inglés.

la dificultad de reconciliar el crecimiento económico con la sostenibilidad y las tensiones que plantea el nexus (Gómez y Naredo 2015) (Giampietro et al., 2013, 2017).[3]

A lo largo de la década de 2010, la crisis de legitimidad de las instituciones europeas parece haberse hecho aún más notable a través de varias señales sintomáticas tales como: a) el resurgimiento de discursos xenófobos y movimientos extremistas "en contra de lo establecido" (llamados también populismos nacionales de extrema derecha) en el espectro político de varios países de la Unión Europea (incluido España), y b) el resultado del referéndum del Brexit en 2016 que marca el inicio de un largo proceso de negociación sobre las condiciones de la salida del Reino Unido de la Unión Europea (Callinicos, 2017; Pirro y Van Kessel, 2018). Fuera del espectro político europeo, la crisis generalizada de legitimidad también se ha hecho bastante notable a través de señales sintomáticas como la elección de Donald Trump como presidente de Estados Unidos a finales del año 2016.

Sin embargo, la profundidad de la crisis de legitimidad parece que sigue sin reconocerse. A nivel internacional, diversas organizaciones al enfrentarse, por ejemplo, a una aparente oposición pública en contra de consejo científico, también restablecen la visión idealizada de la ciencia como proveedor de conocimiento "neutral" o "evidencia" y como fuente de innovación y progreso (American Association for the Advancement of Science, 2017; OECD, 2015; UNESCO, 2016). En la esfera pública y en relación con la cuestión del cambio climático, emergen reacciones ante la elección de Trump como presidente de Estados Unidos tales como "The March for Science", [4] donde se promovieron eslóganes como "Science Speaking Truth to Power", a lo largo de diferentes ciudades del mundo. En formulaciones políticas europeas posteriores a la estrategia EU2020 tales como la economía circular (European Commission, 2015) o la reciente propuesta del Pacto Verde Europeo (European Commission, 2019b), la *innovación* ha ido adquiriendo un creciente protagonismo, anunciando reconciliar objetivos económicos y medioambientales.

Antonio Gramsci ha señalado que: "La crisis consiste precisamente en el hecho de que lo viejo está muriendo y lo nuevo no puede nacer: en este interregnum ocurren fenómenos mórbidos de lo más variados" [The crisis consists precisely in the fact that the old is dying and the new cannot be born; in this interregnum morbid phenomena of the most varied kind come to pass] (Gramsci, 2011: 32-33). En este sentido y a la luz, por ejemplo, de aquellas perspectivas críticas que señalan la dificultad de reconciliar el crecimiento económico con la sostenibilidad, formulaciones como la política europea de la economía circular podrían verse como fenómenos mórbidos que ocurren en el *interregnum.* Concretamente, desde varias perspectivas críticas (ver por ejemplo Cairns y

[3] En este capítulo usamos la versión en inglés (nexus) de la palabra en español "nexo". Desde la economía ecológica, por ejemplo, pensar en el nexus implica señalar tradeoffs planteados por la complejidad de los sistemas socio-ecológicos y tensiones entre el crecimiento económico y la sostenibilidad (Giampietro, 2019).

[4] Ver https://www.marchforscience.com/

Krzywoszynska, 2016; Giampietro et al., 2017; Leese y Meisch, 2015; Stirling, 2015; Voelker et al., 2019), estas formulaciones políticas estarían postulando una gobernanza tecnocrática *de* la complejidad del nexus y dejando las necesidades de los más pobres en un segundo plano. En consecuencia, lo nuevo que aparentemente no puede nacer, sería una gobernanza *en* complejidad *y* para la sostenibilidad medioambiental y la justicia social. En palabras de Voelker et al. (2019), el nexus debería establecerse como un problema político legítimo.

Mientras simpatizamos con el conjunto de perspectivas críticas señaladas anteriormente y compartimos la preocupación por las cuestiones medioambientales y sociales, la presente disertación plantea, por un lado, si las políticas europeas basadas en la innovación podrían estar (re-)adquiriendo su significado de manera interaccional, y paradójicamente, con la gama de perspectivas críticas que destacan tradeoffs del nexus y visibilizan daños sociales. Particularmente queremos desarrollar una mejor comprensión del papel que juega la innovación (como imaginario) al relacionarse con las perspectivas críticas que destacan tradeoffs del nexus y daños infligidos socialmente, de manera que estas relaciones e interacciones podrían permitir la (re-)formulación de las políticas europeas.

Asimismo, en esta disertación, también queremos explorar narrativas que restablecen visiones idealizadas de la ciencia en la esfera pública, entendida como arena epistemológica cívica (Jasanoff, 2005, 2012) en la que se manifiestan visiones culturales acerca de cómo se espera que el conocimiento científico se produzca y se use en procesos de gobernanza. Específicamente, queremos investigar los roles de visiones idealizadas de la ciencia en cuestiones medioambientales que se (re)invocan en narrativas emergentes en la esfera pública, *y* cómo estas narrativas interactúan con perspectivas críticas que abogan por un reconocimiento de la complejidad y la incertidumbre.

En conjunto, a través de esta investigación, queremos desplegar un conjunto de paradojas sobre el *modo* en el que las cuestiones, especialmente medioambientales, se están gobernando, y contribuir a los debates sobre la sostenibilidad. En las siguientes subsecciones desarrollamos esta motivación. Concretamente en la siguiente subsección (1.2) introducimos con más detalle algunas de las perspectivas críticas citadas anteriormente y planteamos las necesidades de la investigación. En la subsección 1.3 concretamos el objeto de estudio y en la última subsección (1.4) introducimos a qué debates se espera contribuir.

1.2 Las necesidades de la investigación

Funtowicz y Strand (2007) han argumentado cómo las instituciones modernas de la ciencia y del Estado, co-evolucionaron bajo un sistema o estrategia dual de legitimidad a través del cual, el Estado apoyó a las instituciones científicas hasta que consiguieron una posición hegemónica como productoras de conocimiento. Simultáneamente, la fundación del Estado se legitimó mediante ese conocimiento y racionalidad científica, bajo la creencia idealizada de que la ciencia era capaz de producir un conocimiento válido, fiable, neutral y objetivo para informar a políticos en el desarrollo e implementación de políticas públicas. En la perspectiva de Latour (2007), las instituciones se engranaron mutuamente bajo la ilusión de demarcación entre, por un lado, los *hechos* de la naturaleza que sería descubiertos por el campo de la ciencia, y, por otro lado, los *valores* pertenecientes al campo de la política y los procesos de decisiones públicas. De acuerdo con Latour (2007), esta demarcación es fruto de un ingenioso trabajo intelectual e ideológico (que él llama trabajo de purificación) que pretende separar la "naturaleza" de la "sociedad", la "política" de la "ciencia", los "hechos" de los "valores". A su vez, este esfuerzo intelectual ha permitido un intenso trabajo de mediación, es decir, más y más híbridos y hechos (por humanos) son establecidos. Por su parte, Rommetveit y Wynne (2017) han señalado una gradual intensificación de las relaciones entre la "ciencia" y la "política" a través de la innovación tecno-científica, la cual se promueve dentro de un discurso neoliberal basado en el crecimiento económico y la creación de mercados libres.

La estrategia dual de legitimidad se ha criticado además por no ser adecuada para tratar cuestiones caracterizadas por condiciones de complejidad y alta incertidumbre desde la ciencia post-normal (Funtowicz y Ravetz, 1993, 2000). En cuanto a la complejidad, Ravetz (1971) distingue entre problemas *prácticos* (i.e., problemas tecnológicos, políticos y medioambientales que muestran complejidad) y problemas *técnicos.* Ravetz (1971) argumenta como la ciencia moderna ha sido particularmente exitosa al basarse en el supuesto de que el problema práctico (o el sistema) es i) simple, de forma que el problema práctico se traduce en un problema técnico que tiene una única solución técnica, o ii) complicado, en el sentido de la suma lineal de problemas simples. En esta línea, pensar que los problemas se solucionan si la complejidad se entiende, sería una inconsistencia pragmática porque implicaría que la complejidad es sencilla y que finalmente se ha encontrado una solución técnica al problema práctico. Similarmente, Funtowicz y Strand (2007) señalan que la estrategia dual de legitimidad (llamada también modelo moderno conceptual) asume que sólo hay una descripción correcta (y completa) del sistema que sería provista por la ciencia y, ésta le diría al político todo lo que necesita saber para la toma de decisiones públicas. Funtowicz (2020) argumenta cómo el problema práctico complejo no puede reducirse a una única visión ante una pluralidad de perspectivas legítimas. En este sentido, la complejidad estaría asociada a una pluralidad de significados (ambigüedad) y un problema práctico podría traducirse a muchos problemas técnicos resultando en múltiples soluciones técnicas "correctas", o incluso podría no haber un problema técnico legítimo y creíble que solucionar. Desde el punto de vista de Wynne (1992), la complejidad está asociada a la indeterminación de un problema práctico, la cual implica a su vez la existencia de una multitud (virtual) de marcos alternativos en los que se puede encuadrar el problema a investigar. La indeterminación también implicaría que la propia formulación del problema cambia en el tiempo y es en sí misma dinámica, de modo que las relaciones de causalidad establecidas también cambian en el tiempo. Los trabajos de Funtowicz y Ravetz (1994), refieren a la complejidad como una característica emergente de los sistemas, en los cuales la intencionalidad está presente. Desde esta perspectiva, los problemas prácticos complejos contienen, para expresarlo en el lenguaje Latourniano (2007), una mezcla híbrida de hechos y valores, sujeto y objeto, naturaleza y cultura, objetos (no intencionales) e intenciones. Por ejemplo, los problemas medioambientales complejos serían el resultado hibrido de nuestras intenciones y elecciones humanas que han tenido consecuencias en los sistemas de la biosfera.

Además de complejidad, los problemas prácticos también se han caracterizado por mostrar incertidumbre (Funtowicz y Ravetz, 1990). De acuerdo con Wynne (1992), en el caso de la indeterminación de un problema práctico subyace una incertidumbre más bien de carácter ontológico que estaría relacionada con la propia formulación y definición del problema. Por su parte, Rittel y Webber (1973) introdujeron el término de problema perverso [wicked problem] para referirse aquellos problemas que no pueden formularse de forma exhaustiva, ya que no se dispone de toda la información necesaria para comprender el problema ni para tratarlo. En esta dirección, Wynne (1992) señala un tipo de incertidumbre a nivel epistemológico denominada ignorancia, la cual se asocia a una situación en la que "no sabemos lo que no sabemos" [we don´t know what we don´t know] (Wynne, 1992:114). Funtowicz y Ravetz (1993) argumentan que el manejo de problemas complejos medioambientales y tecnológicos en condiciones de alta incertidumbre y cuando lo que está en juego es alto, requiere del desarrollo de nuevas interfaces, arreglos institucionales y métodos para tratar con los llamados hechos extendidos o híbridos.

Con respecto a la incertidumbre, la evolución de la relación entre la ciencia y la política de la estrategia dual de legitimidad parece contener una paradoja bastante curiosa (Funtowicz y Strand, 2007). Por un lado, el papel idealizado de la ciencia fue tomando un creciente protagonismo a lo largo del siglo XX, como fuente ilimitada de innovación, desarrollo tecnológico y progreso económico en la formulación de las políticas públicas (Godin, 2006b) (Godin y Vinck, 2017). De modo que, las crecientes prácticas científicas y tecnológicas podrían verse como grandes productoras de incertidumbre al introducir nuevas innovaciones (ej. las biotecnologías, nanotecnologías). Por otro lado, estas prácticas son objeto de regulaciones y decisiones políticas que, a su vez, se asesoran a través de un cuerpo de conocimiento científico que pretende, paradójicamente, reducir o controlar la incertidumbre crecientemente producida. De hecho, los efectos potenciales adversos e inesperados del progreso está siendo cada vez más reconocidos. Por ejemplo, Beck (1992) en su libro "Sociedad del riesgo: Hacia una nueva modernidad", argumenta que estamos viviendo en un tiempo (que él llama segunda modernidad) en el que las sociedades producen no sólo bienes sino también males en forma de riesgos.

En conjunto, desde estas perspectivas críticas, propuestas políticas europeas subsecuentes a la estrategia EU2020 como la economía circular o el pacto verde europeo (European Commission, 2015, 2019b), podrían verse como estrategias cada vez más arriesgadas, ya que la innovación (tecnocientífica) ha ido penetrando de forma creciente en las formulaciones de estas estrategias, y por tanto produciendo más incertidumbre.

Similarmente, desde perspectivas críticas como la economía ecológica y la ecología industrial (que han ido incorporado gradualmente perspectivas sistémicas y comprensiones de las teorías de la complejidad e incluso de la ciencia post-normal), las estrategias políticas mencionadas podrían verse como insostenibles a pesar de anunciar reconciliaciones del crecimiento económico con las cuestiones medioambientales (Kovacic et al., 2019). Particularmente, desde la economía ecológica, tales formulaciones políticas serían vistas como intentos de una gobernanza tecnocrática de los tradeoffs y tensiones del nexus a través de "arreglos técnicos" [technical fixes] y soluciones tecnológicas que tienden a fracasar con los problemas complejos del nexus (Giampietro et al., 2017) (Giampietro, 2019). Del mismo modo, las estrategias podrían verse incluso peligrosas por su carácter neoliberal que tiende, por ejemplo, a agravar problemas sociales de desigualdad (Leese y Meisch, 2015; Arriazu y Solari, 2015)

A pesar de simpatizar con la gama de perspectivas críticas señaladas anteriormente y de compartir la preocupación por las cuestiones medioambientales y sociales, la presente investigación plantea si recientes políticas oficiales europeas basadas en la innovación podrían estar (re-)articulándose al interaccionar con la gama de voces críticas que tienden a señalar tensiones del nexus y daños infligidos socialmente. Concretamente, queremos investigar el papel que está jugando la innovación (como imaginario) en su relación con las voces críticas señaladas, de manera que estas relaciones e interacciones podrían permitir la (re-)articulación de las políticas europeas.

Para abordar esta pregunta de investigación, aplicamos de forma didáctica varios enfoques y perspectivas teóricas para analizar críticamente dos estrategias políticas oficiales europeas basadas en la innovación, prestando especial atención al papel de la innovación (como imaginario) al relacionarse con los tradeoffs del nexus y algunas cuestiones sociales. A su vez, estos análisis críticos (que representan nuestros estudios de caso) son una forma de "hacer zoom" en las perspectivas críticas aplicadas, para posteriormente reflexionar (en la sección 1 del capítulo 5) sobre cómo las políticas europeas podrían (re-)adquirir significado vía innovación al interactuar con nuestras voces críticas.

Asimismo, en nuestra investigación queremos investigar procesos políticos que se desarrollan en la esfera pública (y *fuera* de las políticas oficiales de gobernanza) en una situación generalizada de crisis de legitimidad de las instituciones. Al mismo tiempo, la esfera pública se haya entrelazada estrechamente con la esfera institucional en el sentido de que las visiones culturales y formas epistemológicas que se manifiestan en la esfera pública se insertan en las prácticas y discursos científicos e institucionales que se han ejercido históricamente. Concretamente, queremos (i) investigar posibles roles de visiones idealizadas de la ciencia en cuestiones medioambientales que se (re)invocan en narrativas emergentes en la esfera pública, y (ii) reflexionar como estas narrativas interactúan con posturas críticas que apuntan hacia un reconocimiento de las condiciones de complejidad y la incertidumbre.

Para abordar esta cuestión, analizamos críticamente unas narrativas que (re)invocan creencias idealizadas de la ciencia del clima en el sitio web social "I Fucking Love Science" (en adelante IFLS) en reacción a una señal sintomática de la crisis generalizada de legitimidad: la elección de Trump como presidente de Estados Unidos en 2016. De forma más específica, analizamos críticamente la narrativa que encontramos más predominante en la web social a través de dos perspectivas que abogan por un reconocimiento de la complejidad y la condición de alta incertidumbre en cuestiones medioambientales. Este análisis crítico es también concebido como un ejercicio didáctico que nos servirá para reflexionar sobre las interacciones entre dicha narrativa y las perspectivas críticas aplicadas.

El carácter didáctico de nuestros análisis críticos está relacionado además con una especificidad que Latour (2007) ha señalado. Interesantemente, Latour (2007) ha señalado una falsa conciencia asociada a posturas críticas que se dirigen hacia discursos y narrativas modernas de progreso científico, desarrollo tecnológico, innovación, etc., y, paradójicamente, se autoengañan creyendo que no están asumiendo de forma implícita supuestos epistemológicos y especificidades de aquello que se critica. De acuerdo con Latour (2007), el aspecto irónico de esta condición (moderna), es que la postura crítica podría reforzar aquello que la misma crítica trata de abolir. Teniendo en cuenta esta condición, en nuestra investigación tratamos de hacer un ejercicio didáctico y reflexivo sobre posibles supuestos implícitos *modernos* adoptados en nuestros análisis "críticos". Dicho de otra manera, los analíticos críticos desarrollados en esta investigación son entendidos como caminos de aprendizaje para desplegar una creciente consciencia de nuestros propios sesgos de acción occidentales. Desde este punto de vista, la investigación *per se* no es una tarea fácil y se requieren análisis en profundidad que no están exentos de desafíos.

En la siguiente subsección introducimos con más detalle las específicas estrategias políticas europeas y narrativas emergentes en la esfera pública que constituyen los estudios de caso y porqué se han elegido como tales. Específicamente, estos casos son introducidos desde el marco general de trabajo que hemos aplicado para aproximarnos al objeto de investigación.

1.3 Marco de trabajo y objeto de estudio

Para aproximarnos al objeto de investigación, hemos tomado como marco de trabajo general el enfoque del análisis situacional desarrollado por Clarke (2005). Este enfoque, con raíces en el interaccionismo simbólico y la filosofía pragmática, pone énfasis en la situación compleja de la investigación ampliamente concebida. Esto significa situar la investigación culturalmente, simbólicamente, institucionalmente, visualmente, conceptualmente o discursivamente. Siguiendo esta línea de pensamiento, nuestro objeto de estudio se focaliza en determinados procesos políticos—estrategias políticas oficiales europeas basadas en la innovación y narrativas emergentes en la esfera pública y basadas en visiones idealizadas de la ciencia— que se articulan en una situación de crisis generalizada de legitimidad de nuestras instituciones científicas y de gobernanza. A continuación, introducimos con más detalle el objeto de estudio de cada uno de los tres estudios de caso desarrollados en la investigación.

i. *Políticas europeas basadas en la innovación*.

En los dos primeros estudios de caso, abordamos dos políticas oficiales europeas basadas en la innovación, motivada por la necesidad de comprender mejor cómo nuestras instituciones europeas de gobernanza funcionan, cómo se (re)legitiman en una situación de crisis de legitimidad, qué supuestos hacen y necesitan hacer. En el campo específico de la (re-)formulación de una política, el enfoque de Clarke (2005) implica que el objeto de investigación no es el contenido de la política o el discurso político como tal, sino la situación compleja en la que esa política se construye y (re-)adquiere su significado. Es decir, este enfoque implica elucidar las condiciones, los actores, sus creencias, los tipos de pensamientos, omisiones, conflictos y controversias que hacen posible y permiten darle significado. Dicho de otra manera, estos elementos no son el contexto de la política, todo esto *es* la política.

Concretamente, en *el primer estudio de caso* abordamos el discurso político de la Estrategia Europa 2020 (European Commission, 2010a) que recoge como la Comisión Europea visualiza la recuperación de la Unión Europea tras la crisis financiera de 2007-2008 a través de un crecimiento inteligente, sostenible e inclusivo basado en la innovación. En este sentido, la innovación se proyecta como un prometedor salvoconducto no sólo para los problemas económicos, sino para los medioambientales y sociales. En este estudio de caso, sin embargo, no tratamos de contrastar percepciones o comprobar el éxito (o fracaso) de los objetivos inicialmente propuestos dentro de la estrategia. De hecho, posteriores evaluaciones realizadas por la propia Comisión Europea muestran, por ejemplo, que los objetivos marcados en relación a la pobreza estaban lejos de alcanzarse (European Commission, 2014c, 2014a). La elección de este estudio de caso, viene motivada por la necesidad de entender mejor el papel de la innovación (como imaginario e idea) al relacionarse con las tensiones y tradeoffs del nexus y algunos problemas sociales, de forma que estas relaciones permiten que el discurso adquiera parte de su significado. Siguiendo la línea de Clarke (2005), los diferentes actores institucionales que toman parte en visualizar y proyectar un futuro deseable tras la crisis financiera, sus creencias y pensamientos, sus omisiones, sus asuntos de preocupación e interés, sus valores en conflicto, no son el contexto de la estrategia política.

Más bien, todo esto constituye el proceso de construcción de significado del discurso de la estrategia a través de la innovación en una situación de crisis severa de legitimidad. Específicamente, desde la tradición teórica de análisis discursivo de Foucault (2008), analizamos críticamente el papel que juega la innovación (como imaginario) en la gobernanza del nexus y en la formulación del discurso idealizado de la EU2020 sobre el "crecimiento sostenible". Simultáneamente, investigamos que implicaciones ejerce el discurso *para* la gobernanza del nexus, y algunas cuestiones sociales como la desigualdad y ciertos aspectos del bienestar humano.

Este análisis crítico es concebido como un ejercicio didáctico sobre el que reflexionamos en la sección 1 del capítulo 5, y de forma conjunta con las lecciones aprendidas en el segundo estudio de caso, con el objetivo de comprender mejor el proceso de (re-)construcción de significado de recientes políticas oficiales europeas.

En formulaciones políticas posteriores a la estrategia EU2020 tales como la Economía Circular (European Commission, 2015), la innovación se ha ido convirtiendo en un creciente recurso. En el *segundo estudio de caso* abordamos dicha política formulada a mediados de la década de 2010 para fomentar la recuperación económica tras la crisis financiera de 2007-2008 y conciliar dicha recuperación con las preocupaciones y problemas principalmente medioambientales. La importancia y elección de esta política como estudio de caso también se explica porque esta política se ha ido rehaciendo y cambiando, y actualmente es uno de los ejes centrales del denominado Pacto Verde Europeo (European Commission, 2019b). A medida que escribimos (año 2022) esta política se sigue (re) haciendo. De forma similar al primer estudio de caso, el objeto de estudio no es el contenido específico del discurso de la política como tal, sino la situación compleja ampliamente concebida en la que el discurso se articula y adquiere significado. En este sentido, el grupo de actores que proyectan un futuro deseable, los tipos de creencias que promueven, sus dilemas y conflictos, sus asuntos de interés, sus preocupaciones y omisiones, constituyen el proceso de (re-)construcción de significado del discurso a través de la innovación (como imaginario), en una situación dónde la crisis de legitimidad del proyecto europeo se ha hecho aún más notable. Como ya introducimos anteriormente, la emergencia de partidos extremistas en muchos países europeos con discursos xenófobos y separatistas, y el referéndum del Brexit celebrado en 2016, son algunas señales sintomáticas de esta crisis.

Concretamente, en este estudio de caso queremos desarrollar una mejor comprensión del papel que la innovación (como imaginario e idea) juega al interactuar con el nexus (como pensamiento tendente a señalar tradeoffs, tensiones y límites biofísicos). De forma que tales interacciones podrían permitir la (re-)construcción de significado de la política de la economía circular. En otras palabras, analizamos cómo la política podría (re-)hacerse en "dependencia constitutiva" (Clark y Chalmers, 1998) con el nexus y a través del imaginario(s) de innovación. Para ello, tratamos de aplicar una distancia analítica entre la "innovación", el "nexus" y las "políticas" (y discursos políticos), y conceptualizar críticamente sus interacciones como parte de un proyecto político europeo que trata de (re)legitimarse en una situación de crisis de legitimidad, y no como un desarrollo inevitable. De forma más específica, analizamos estas interacciones y relaciones a través de la combinación de dos perspectivas teóricas (Allenby y Sarewitz, 2011; Giampietro et al., 2014, 2019) que reflexionan sobre los problemas y tensions del nexus en el nivel de sistema de gobernanza medioambiental

ii. Narrativas basadas en la ciencia en la esfera pública.

De forma paralela a cómo las políticas europeas basadas en la innovación se están (re-)formulando en una situación de crisis generalizada de legitimidad de las instituciones, visiones idealizadas de la ciencia en cuestiones medioambientales se (re)invocan en diversas narrativas desarrolladas en la esfera pública en dicha situación de crisis. En el tercer estudio de caso, analizamos críticamente unas narrativas que se desarrollan en reacción a la elección de Donald Trump como presidente de Estados Unidos en 2016 y (re)invocan creencias idealizadas de la ciencia en la cuestión del cambio climático en el sitio web social "I Fucking Love Science" (en adelante IFLS). La elección de estas narrativas como estudio de caso, está motivada por la observación de que la web "IFLS" fue un espacio on-line de creciente interacción social en reacción a la elección de Trump como presidente de Estados Unidos. Y en dicho espacio, (re)emergieron determinadas visiones culturales y epistemológicas sobre el papel de la ciencia en gobernanza y la sociedad, que son el reflejo de discursos y prácticas de legitimación que se han ejercido históricamente desde nuestras instituciones científicas y de gobernanza. La elección de Trump como presidente es además entendida como una señal sintomática de la situación de crisis generalizada de legitimidad de las instituciones.

Siguiendo la línea de pensamiento de Clarke (2005) que hemos aplicado en los casos anteriores, en este caso el objeto de investigación no es el contenido de las narrativas como tal, sino la situación ampliamente concebida en la que dichas narrativas se desarrollan y adquieren significado. Es decir, el grupo de actores (en este caso una comunidad online), sus intereses, sus motivos de preocupación (ej. cuestiones medioambientales), sus creencias, las instituciones científicas que históricamente han promovido dichas creencias (ej. El Panel Intergubernamental sobre Cambio Climático) constituyen el proceso de construcción de significado de las narrativas en una situación de crisis generalizada de legitimidad de las instituciones.

Específicamente, en este estudio de caso, analizamos críticamente la narrativa que hallamos más predominante en la web social y que (re)invoca visiones idealizadas de la ciencia del modelo moderno y del modelo del déficit público, a través de dos principales perspectivas críticas. Estas perspectivas abogan por un reconocimiento de la complejidad y la condición de alta incertidumbre en cuestiones medioambientales y son aplicadas de diferente modo. Por un lado, *revisamos* la crítica de Irwin y Wynne (1996) del modelo del déficit público con el objeto de explorar si el diálogo público sobre la cuestión del cambio climático podría estancarse al dirigir dicha postura crítica hacia la narrativa retada. Por otro lado, criticamos la narrativa en la línea de Funtowicz y Ravetz (1993) y Funtowicz y Strand (2011). Dicha postura crítica adoptada, aboga por el reconocimiento de las condiciones de la complejidad y la incertidumbre científica, y bajo esta última condición, tratamos de desplegar criterios para tratar con la cuestión del cambio climático.

En la sección 2 del capítulo 5, (i) discutimos primero posibles roles de aquellas visiones idealizadas de la ciencia que se (re)invocan en la narrativa retada, y (ii) posteriormente reflexionamos de forma conjunta cómo ambas perspectivas críticas aplicadas están interaccionando con esta narrativa retada. En este último sentido, el análisis crítico llevado a cabo a través de ambas perspectivas críticas, es concebido como un ejercicio didáctico en su conjunto.

Asimismo, queremos destacar que al revisar la postura crítica de Irwin y Wynne (1996), encontramos un implícito paralelismo con el pensamiento del nexus y la discusión de tradeoffs y tensiones que se abre desde las teorías de complejidad. Este paralelismo será introducido con más detalle en la sección 4.3 de este capítulo y nos permitirá reflexionar de manera transversal sobre el conjunto de perspectivas críticas aplicadas en todos los estudios de caso en la sección 3 del capítulo 5.

A continuación, concluimos exponiendo a qué debates queremos contribuir con esta disertación.

1.4 Contribución al debate.

En esta investigación exploramos varios procesos políticos en dos esferas que se hayan entrelazadas: la esfera institucional donde se articulan políticas europeas oficiales basadas en la innovación, y la esfera pública, donde se manifiestan visiones epistemológicas que se han coproducido con las prácticas y discursos tecnocientíficos e institucionales que se han ejercido históricamente (Jasanoff, 2005, 2012).

Concretamente, a través de los dos primeros estudios de caso investigamos de forma didáctica el papel de la innovación (como imaginario) al interaccionar con el nexus y algunas cuestiones sociales, a través de varias perspectivas críticas. Estos estudios de caso nos permitirán responder a la pregunta de si (y de qué modo) las políticas europeas podrían (re-)formularse al interactuar con posturas críticas que destacan tradeoffs del nexus y daños infligidos socialmente. Asimismo, a través del tercer estudio de caso, analizamos críticamente narrativas que (re)invocan visiones idealizadas de la ciencia en la cuestión del cambio climático en el sitio web social IFLS. Específicamente, aplicamos dos perspectivas críticas que abogan por un reconocimiento de la complejidad y la incertidumbre en cuestiones medioambientales hacia la narrativa más predominante de la web social. Este estudio de caso, nos servirá para i) identificar posibles roles de visiones idealizadas de la ciencia en cuestiones medioambientales que se promueven en narrativas en la esfera pública, y ii) reflexionar cómo estas narrativas interaccionan con perspectivas críticas que inciden en el reconocimiento de la complejidad y la incertidumbre.

En conjunto, a través de esta disertación y desde una postura autorreflexiva y moral, queremos desplegar un conjunto de paradojas y lecciones de aprendizaje sobre el *modo* en el que las cuestiones económicas, sociales y medioambientales se están gobernando. Especialmente, queremos contribuir a los debates sobre la sostenibilidad y la gobernanza medioambiental. Nuestra contribución espera ser constructiva en el sentido de estimular el debate sobre qué tipo de gobernanza y teoría de cambio (y acción) deseamos, a la luz de las paradojas identificadas.

En la próxima sección 2, introducimos de forma sintetizada el objetivo general, las preguntas de investigación y los objetivos específicos que se persiguen a través de los estudios de caso.

2. Objetivos de la investigación

En esta sección presentamos las preguntas de investigación y los objetivos a partir de una breve recapitulación de la motivación introducida en la sección anterior.

Nuestra investigación viene motivada por la necesidad de explorar determinados procesos políticos que se articulan en dos esferas interrelacionadas — (i) estrategias políticas europeas basadas en la innovación en la esfera institucional y (ii) narrativas que (re)invocan visiones idealizadas de la ciencia en cuestiones medioambientales en la esfera pública —en una situación de crisis generalizada de legitimidad de nuestras instituciones científicas y de gobernanza.

Estas necesidades se desglosan en las dos siguientes principales preguntas de investigación, las cuales a su vez se articulan en tres objetivos específicos relacionados con los estudios de caso:

a) ¿Si y de qué modo las políticas europeas basadas en la innovación podrían estar (re-) adquiriendo significado al interaccionar con perspectivas críticas que destacan tradeoffs del nexus y daños infligidos socialmente?

Concretamente, queremos investigar el papel que juega la innovación (como imaginario) al interactuar con dichas perspectivas críticas, de forma que estas relaciones e interacciones podrían permitir que las políticas europeas (re)adquieran significado. Esta pregunta de investigación se aborda a través de los dos siguientes objetivos específicos que se relacionan con los dos estudios de caso respectivamente:

a.1. Analizar críticamente el papel del imaginario de la innovación en la gobernanza del nexus y en la formulación del discurso de la estrategia EU2020 sobre el "crecimiento sostenible", y explorar las implicaciones del discurso para la gobernanza del nexus y algunos aspectos sociales.

a.2. Desarrollar una mejor comprensión del papel del imaginario de la innovación en (y para) la gobernanza del nexus en la política europea de la economía circular.

En la sección 1 del capítulo 5, reflexionamos sobre los resultados de estos dos estudios de caso para responder a la primera pregunta de investigación.

b) ¿Cuáles son los posibles roles de visiones idealizadas de la ciencia en cuestiones medioambientales que se promueven en narrativas emergentes en la esfera pública, y cómo estas narrativas interactúan con perspectivas críticas que abogan por un reconocimiento de la complejidad y la incertidumbre?

Esta pregunta de investigación se aborda a través del siguiente objetivo específico que se relaciona con el tercer estudio de caso:

b.1. Analizar críticamente las visiones idealizadas de la ciencia del clima que se promueven en las narrativas que se articulan en el sitio web social "I Fucking Love Science (IFLS)

En la sección 2 del capítulo 5, discutimos los resultados de este estudio de caso para dar respuesta a la segunda pregunta de investigación.

En las siguientes secciones (3 y 4) introducimos con más detalle a la innovación (como imaginario) y al pensamiento del nexus, debido a que sus relaciones son abordadas de forma amplia en el conjunto de la investigación, concretamente en el primer estudio de caso y de forma más extensiva, en el segundo estudio de caso. En la sección 5, introducimos los específicos marcos teóricos-metodológicos aplicados para la consecución de todos los objetivos específicos señalados anteriormente.

3. La innovación

En esta sección realizamos una introducción más detallada sobre la "innovación". Concretamente, en la primera subsección (3.1), realizamos un breve recorrido histórico sobre la noción de innovación y señalamos que la innovación es mejor comprendida en esta investigación como un *imaginario*. En la segunda subsección (3.2), "hacemos zoom" y exploramos cómo este imaginario es co-creado a lo largo del siglo XX a través de diferentes comunidades académicas y bajo diferentes perspectivas. En la tercera subsección (3.3), realizamos un breve recorrido de la reciente movilización de la innovación en el plano político europeo. Y en la última subsección (3.4), introducimos brevemente cómo el imaginario de innovación se relaciona con los dos primeros objetivos específicos de nuestra investigación.

3.1 Breve recorrido histórico sobre la noción de innovación. La innovación como imaginario

La noción en sí misma de innovación ha cambiado de significado varias veces a lo largo de la historia. Antes del siglo XX, la innovación solía tener una connotación negativa, relacionada con la herejía o con algo que aparenta ser nuevo, pero es una representación poco cuidadosa de algo viejo (Godin, 2014b). Sin embargo, la innovación pasó a ser visto como algo predominantemente positivo, hasta el punto que en la actualidad es ampliamente concebido como un (casi) incuestionable *bien* público (Godin y Vinck, 2017). Esta evolución del término se produce dentro de un cambio cultural más amplio en las civilizaciones de Occidente entre el siglo XIX y XX, en el que se adopta lo nuevo y la novedad como algo deseable y bueno en sí mismo, y bajo la idea influyente de progreso y utilidad (Godin, 2014a).

Godin (2006b) argumenta cómo diferentes comunidades científicas (investigadores académicos e industriales, escuelas de negocios, economistas y estadísticos) contribuyeron, en diferentes periodos a lo largo del siglo XX, a desarrollar la *creencia* conocida como el modelo lineal de la innovación. Dicho de otro modo, la innovación fue narrada y (re)construida conceptualmente en términos de un modelo lineal a lo largo del siglo XX. A groso modo, este modelo postula los siguientes pasos secuenciales y unidireccionales a través de los cuales el desarrollo científico-tecnológico contribuirían a la economía: la investigación básica proporciona descubrimientos que son retomados por la investigación aplicada para ser transformados en invenciones. Estas invenciones se desarrollan en forma de tecnologías, las cuales son a su vez desarrolladas con el objeto de ser comercializadas en el mercado como productos y servicios, y dicha expansión y difusión de productos y servicios contribuye al crecimiento económico.

Esta retórica se convirtió en un elemento central en las narrativas políticas basadas en la innovación durante el periodo posterior a la Segunda Guerra Mundial en Europa y América del Norte (Strand et al., 2016) y suele asociarse al Informe de Vannevar Bush titulado "La Ciencia-la frontera sin fin" (Bush, 1945) dirigido hacia el presidente de Estados Unidos. Sin embargo, dicho informe no hacía, sino que reforzar parte de una retórica política que se había articulado desde principios del siglo XX (Godin, 2006b). Asimismo, la articulación de estas retóricas políticas se produce durante una expansión exponencial de recursos e inversión en ciencia (Price, 1963).

Paralelamente, la noción de innovación va a ser gradualmente redefinida a partir de la mitad del siglo XX, desde diferentes enfoques académicos y a través de un conjunto de relaciones no lineales y más complejas entre elementos como: la investigación científica básica y aplicada, la investigación y desarrollo, el desarrollo tecnológico, las tecnologías de la información y comunicación, la industria, la ingeniería, empresas de negocios, el sistema educativo, el conocimiento técnico y el crecimiento económico. Simultáneamente, muchas de estos enfoques analíticos y construcciones conceptuales de la innovación convergen en el contexto político europeo, de tal forma que la innovación es movilizada cada vez más en un amplio rango de dominios políticos y sectoriales y niveles de gobernanza (nacional, regional etc.) (Rommetveit et al., 2020). Estas movilizaciones son ejemplificadas a través de enfoques recientes orientados a transformaciones sociotécnicas a gran escala como la Cuarta Revolución Industrial (European Commission, 2016), el Pacto Verde Europeo (European Commission, 2019b) o el enfoque orientado a implementar los Objetivos de Desarrollo Sostenible de la Agenda de las Naciones Unidas (European Commission, 2020b). En estos ejemplos, un amplio número de problemas sociales y medioambientales que se extienden a lo largo de dominios políticos y sectoriales se redefinen y se (re)imaginan a través de la innovación como medio para abordar tales problemas. Por tanto, podemos hablar aquí de un *imaginario* de innovación, entendido como un conjunto de significados y representaciones sostenidas de forma colectiva que se han (re)construido históricamente (y continúan en reconstrucción) a través de diferentes comunidades académicas y políticas (Taylor, 2002) (Pfotenhauer y Jasanoff, 2017).

En la siguiente subsección, "hacemos zoom" en el proceso de construcción de este imaginario a lo largo del siglo XX, observando cómo algunas comunidades académicas y científicas tomaron parte en su construcción, tanto en términos de un modelo secuencial como de proyecciones más complejas y no lineales entre varios elementos. En la subsección 3.3, introducimos con más detalle la movilización de la innovación en el plano político europeo.

3.2 La innovación en la literatura científica-académica

Godin (2006b) argumenta como desde principios del siglo XX, científicos de las ciencias naturales preocupados por el soporte público a la investigación básica, promovieron la idea de que este tipo de investigación era fuente de investigación aplicada. Posteriormente, investigadores de escuelas de negocios añadieron un eslabón más a esta relación: la gestión industrial de la investigación aplicada y el desarrollo experimental en forma de tecnologías. De este modo, desde la década de los 60, la "investigación" se encontraba redefinida en muchos círculos políticos oficiales (ej. la OECD) como Investigación y Desarrollo (I+D), lo cual hacía referencia a: investigación básica o fundamental, investigación aplicada y desarrollo tecnológico (Godin, 2005). A partir de esta década, diversos economistas e investigadores de las escuelas de negocios, inspirándose usualmente en las ideas de Schumpeter (1939) (citado en Godin, 2006b), extendieron el modelo hacia una dimensión mayor: conducir el desarrollo tecnológico hacia la producción comercial.

Godin (2006b) argumenta como la innovación se introdujo en la teoría económica a través de Schumpeter, quién ciertamente realiza la distinción entre invención, innovación y difusión, pero considera que la invención *no* inducía innovación necesariamente. La invención se consideraba un acto de creatividad intelectual sin mucha relación con su uso económico. En cambio, la innovación (inicial) se relacionaba con el desarrollo de un nuevo producto, un nuevo tipo de materia prima, una nueva combinación de los mismos recursos productivos, una nueva idea de modelo de negocio o una novedad técnica u organizacional. La innovación (por imitación o difusión) serían decisiones del emprendedor en el ámbito económico-empresarial relacionadas con un uso económico, productivo o comercial (Godin, 2006b). Por tanto, a pesar de esta escasa dependencia entre invención e innovación profesada, se realizan varias interpretaciones secuenciales que conectan el papel de la ciencia pura y la invención, con su propagación en la industria y uso comercial.

Asimismo, a partir de la década de los sesenta, la noción de innovación va a ser crecientemente redefinida en el plano académico desde diferentes perspectivas analíticas y a través de la relación (no lineal) de varios elementos, entre los que usualmente se encuentra la Investigación y el Desarrollo. Muchas de estas perspectivas se inspiran en los trabajos de Schumpeter realizando diferentes interpretaciones y readaptaciones que se encuentran a veces en disputa. A su vez, las fuentes de inspiración teórica de Schumpeter han sido objeto de debate, ya que Schumpeter parece combinar diferentes líneas de pensamiento tales como el marxismo, el pensamiento de la Escuela Histórica Alemana en Economía, el enfoque de la economía evolucionaria e incluso algunos elementos del pensamiento neoclásico (Fagerberg, 2003).

El objetivo de esta subsección, no es contribuir a los debates sobre qué (y cómo) Schumpeter tomó de aquella fuente teórica o filosófica. Tampoco se desea contribuir a los análisis comparativos entre el pensamiento de Schumpeter y sus posteriores interpretaciones. El objetivo es ilustrar, a groso modo, *la diversidad* de visiones, (re)adaptaciones e interpretaciones que se formulan sobre la innovación a partir principalmente de mediados del siglo XX.

i. La innovación en la economía evolucionaria

Fagerberg (2003, 2004) hace referencia a Schumpeter como protagonista clave en el enfoque de la economía evolucionaria. Para este autor, la innovación (Shumpeteriana) es entendida como el factor fundamental que provoca un cambio cualitativo a través del tiempo y desde dentro del sistema económico. En este caso, la innovación está asociada no sólo a la introducción de una nueva tecnología (ej. maquinaria), sino al desarrollo de un nuevo producto, un nuevo tipo de materia prima o producto intermedio, una nueva combinación de recursos o incluso una nueva forma de organización empresarial. Sin embargo, como la innovación y la creación de novedad ocurren, permanecen todavía sin responder (Fagerberg, 2003: 30). Fagerberg (2003) señala además que Schumpeter estaba en desacuerdo con los enfoques neoclásicos de equilibrio estático, dado que el cambio cualitativo provocado por la innovación irrumpiría cualquier equilibrio estacionario teorizado de una economía. Sin embargo, Schumpeter parece adoptar la visión microeconómica de este pensamiento para explicar la interacción de actores individuales, concretamente entre aquel que introduce la innovación (llamado emprendedor) y una masa de imitadores.

De acuerdo con Fagerberg (2003), ideas centrales de la economía evolucionaria aparecerán de forma implícita en una serie de trabajos en la década de los 60, y de forma más explícita a través de una variada literatura en la década de los 80. En los dos siguientes párrafos, introducimos brevemente algunas de estas tradiciones literarias que se hayan vinculadas entre sí, prestando atención a como la noción de innovación se va a ir (re)definiendo a través de la Investigación y el Desarrollo.

En la década de los 80, se desarrolla una corriente de investigación aplicada en la que la innovación se asocia con la creación de nueva tecnología, y esto se emplea como factor primario para explicar diferencias y patrones de crecimiento económico y comercio internacional. En este sentido, la innovación se mide a través del uso extensivo de datos sobre Investigación y Desarrollo y estadísticas de patentes. Paralelamente, se distingue otro campo de investigación en el que la innovación-difusión (tecnológica) se estudia desde una perspectiva *sistémica*, donde destacan los trabajos de Freeman (1991), citado por Fagerberg (2003). Es decir, las innovaciones son vistas como generadoras de efectos multiplicadores en la economía como un todo, induciendo otras innovaciones que conducirían a un largo periodo de crecimiento económico. Bajo esta perspectiva sistémica, se introdujo otro elemento en el análisis: los factores sociales, organizacionales e institucionales que podrían permitir y facilitar el proceso de innovación-difusión (ver, por ejemplo, Pérez, 1983). Concretamente, dos grupos de autores centraron sus esfuerzos en analizar aquellos factores a nivel nacional, a través del concepto de "sistemas nacionales de innovación". Por un lado, las investigaciones de Freeman (1995) y Nelson (1993) (citado por Fagerberg, 2003), tratan de identificar aquellos actores privados y públicos e instituciones cuya actividad se basa o pueden influir en la Investigación y Desarrollo. Por otro lado, para Lundvall (1992), un "sistema nacional de innovación" está asociado con los procesos de aprendizaje derivados de la interacción entre diferentes instituciones (departamentos de I+D, laboratorios púbicos, universidades, institutos de investigación, instituciones financieras, empresas, etc.) en la producción, difusión y uso de conocimiento nuevo y económicamente útil. Otros autores enfatizan el "sistema de innovación" a nivel local o regional e incluso "sectorial".

Asimismo, la innovación empieza a redefinirse de manera más formal en los modelos de evolución económica a través de Nelson y Winter (1982), citado por Fagerberg (2003). De acuerdo con este autor, Nelson y Winter (1982) aplican la visión microeconómica de Schumpeter sobre agentes e individuos heterogéneos al nivel de la empresa para estudiar la innovación (tecnológica) como el motor principal del crecimiento económico a largo plazo. De este modo, la innovación es más bien proyectada como un fenómeno organizacional, a través del cual las empresas inician la búsqueda de nuevas y más eficientes rutinas en ciertos momentos, dicha búsqueda depende estrechamente del gasto en costes como la Investigación y Desarrollo.

ii. La innovación en las teorías de crecimiento endógeno y la economía del conocimiento

Paralelamente a este desarrollo de la literatura de la economía evolucionaria, la innovación va a ser redefinida a través de las llamadas "teorías de crecimiento endógeno" (Arrow, 1962) (Romer, 1986, 1990) Lucas (1988). Estos economistas van a retomar el influyente modelo neoclásico de Solow (1957) que fue desarrollado para explicar el crecimiento económico. En el modelo de Solow, el crecimiento económico era el producto de los inputs de capital y el trabajo, corregidos por un factor "multiplicador" ya que buena parte del crecimiento no podía ser explicado por aquellos inputs. El factor "multiplicador" también se le denominó "factor residual" a pesar de que era bastante substancial en las mismas simulaciones de Solow. Este factor incluía todo tipo de cambio (incluido cambio técnico) que podría tener un efecto acumulado en el crecimiento económico, pero dejaba sin explicarse. En estudios posteriores neoclásicos, el factor multiplicador se relaciona con el "stock de conocimiento" (Griliches,1979), el cual era asumido como un bien público puro dentro de una economía que operaba bajo el supuesto de competencia perfecta.

A diferencia de estos modelos "residuales", donde la tasa de crecimiento económico a largo plazo venía "dada" de forma exógena, Lucas (1988) y Romer (1986, 1990) desarrollaron modelos en los que dicha tasa venía "dada" (y definida) de forma endógena, y era consecuencia de las acciones de varios agentes económicos (incluidos empresas e instituciones públicas). A groso modo, las teorías de crecimiento endógeno postularon que el crecimiento económico a largo plazo vendría dado por una llegada de innovación a través de dos principales mecanismos interconectados: a) el capital humano (principalmente a través de la educación y de procesos de aprendizaje tales como el llamado "aprendiendo al hacer" (Arrow, 1962)), y b) el cambio tecnológico que provenía de la inversión pública y privada en Investigación y Desarrollo.

De acuerdo con Fagerberg (2003), la visión de la innovación que se postula en estas teorías se aleja bastante de la visión Schumpeteriana, donde la innovación residía más bien en el ámbito del emprendedor (entendido como agente heterogéneo) y se asociaba a la creación de nuevas formas de combinar recursos, equipos, tecnologías, etc. a partir del conocimiento existente (técnico y práctico) en un ambiente caracterizado por la incertidumbre. En contraste, en las teorías endógenas, el conocimiento se asume como un "bien público" *y* parcialmente "excluible" a través, por ejemplo, del uso de derechos de propiedad intelectual (ej. patentes). Al ejercer estos derechos, se espera que el innovador obtenga un incentivo económico y aumente el "stock del conocimiento público" de forma general, lo cual facilitaría la difusión de nuevas innovaciones dado que el conocimiento podría usarse por otros agentes.

Por su parte, Godin (2006a) expone cómo distintas visiones de la innovación que provienen tanto de la literatura sobre crecimiento endógeno como de los "sistemas nacionales de innovación" (concretamente del grupo de autores liderado por Lundvall, 1992), junto el concepto de "la sociedad de la información", se sintetizan bajo el concepto de la *economía del conocimiento*. De acuerdo con Godin (2006a), el trabajo conceptual en torno a este concepto puede rastrearse al menos hasta la década de los años 60, pero es en los años 90 cuando esta noción resurge popularizándose principalmente en Europa, a través de los discursos políticos de la OECD (OECD,1995) (Foray y Lundvall, 1996). Godin (2006a) señala que a través de este concepto se relanza concretamente el papel del conocimiento y las aplicaciones de tecnologías de la información y la comunicación (TIC) en la economía, y promueve el desarrollo de estadísticas específicas para su propia medición (ej. indicadores tales como co-patentes entre industria y universidad) (para más detalle, ver el Apéndice I en Godin, 2006a). A su vez, tal concepto se va a definir y cristalizar con la ayuda de las estadísticas que (auto) promueve, de forma que la relación entre construcción conceptual y estadística es doble y se refuerza (Godin, 2006a).

iii. La innovación disruptiva y su relación con la "destrucción creativa"

La innovación también se ha redefinido a través de teorías económicas como las del "El dilema del innovador" desarrollada por Clayton M. Christensen (Christensen, 1997, citado por Lepore, 2014). De acuerdo con Lepore (2014), Christensen formula un modelo predictivo de éxito empresarial basado en la "innovación disruptiva" bajo el cual, una compañía debe irrumpir continuamente en el mercado con nuevos productos de tecnología (más baratos y de baja calidad) para no fracasar y ser devorada por otras empresas que, supuestamente, tratarían de competir y provocar similares disrupciones. Lepore (2014) señala que esta teoría, interpretada de la teorización que Schumpeter realiza sobre la "destrucción creativa" de las innovaciones, se desmantela a través numerosos ejemplos de experiencias de compañías. De acuerdo con la autora, la innovación disruptiva se ha tratado además de extender desde el campo empresarial hacia otros campos como la educación, la atención médica y el campo digital a través de una creciente literatura.

A continuación, "hacemos zoom" en algunas perspectivas que han estudiado la teorización que realiza Schumpeter sobre la "destrucción creativa", y contrastamos cierto paralelismo que comparten dichas perspectivas con la idea de innovación disruptiva formulada por Christensen.

Desde el punto de vista de Elliott (1980), la idea de "destrucción creativa" aparece en el libro "Capitalismo, Socialismo y Democracia" de Schumpeter y está ampliamente inspirada en Karl Marx. Según Elliott (1980), Schumpeter mencionó, de forma similar a Marx, la "destrucción creativa" para referirse al proceso que acompaña a la ola de innovaciones acaecidas durante la transición de una sociedad feudal hacia una sociedad más capitalista. En este sentido, las innovaciones implicaban una destrucción de lo anterior, es decir, de aquella previa estructura económica, modelo productivo, forma organizacional o método de producción feudal. Sin embargo, Schumpeter pareció además mostrarse escéptico acerca de que este proceso pudiera sostenerse en el tiempo y percibía al capitalismo como un proceso que tiende a socializarse en sí mismo (Elliott, 1980: 64) .Según Elliott (1980), Schumpeter también analiza de forma bastante similar a Marx el proceso de innovación-competición-reducción de beneficios: el capitalismo introducía incesantemente nuevas y más eficientes máquinas y nueva división del trabajo para mejorar la productividad y obtener beneficios extraordinarios. Sin embargo, esta posición privilegiada no podría prolongarse mucho tiempo porque otros capitalistas competirían por introducir las mismas máquinas y la misma división del trabajo.

Según Fagerberg (2003), Schumpeter extiende la idea de Marx de que la evolución capitalista se produce a través de una competición tecnológica entre empresas e introduce una noción de innovación más amplia. De acuerdo con este investigador, Marx sugiere que las empresas capitalistas, para mantenerse competitivas, tratarían de incrementar la productividad (*con éxito o no*) a través de la introducción de nuevas tecnologías más eficientes. De modo, que habría empresas que tendrían éxito al introducir nuevas tecnologías y tendrían beneficios por encima de la media habitual y otras que fracasarían y tenderían a desaparecer del mercado. Por su parte, Schumpeter asocia la innovación no sólo a la tecnología o maquinaria, sino a nuevos productos, nuevas formas de organizar el negocio, nueva combinación de recursos intermedios, etc. Asimismo, los beneficios extraordinarios asociados a estas innovaciones desaparecían a medida que una masa de imitadores introduciría estas innovaciones de forma exitosa.

Reinert, H. y Reinert, E.S. (2006), argumentan que el término de "destrucción creativa" se filtra en Schumpeter vía Werner Sombart, perteneciente a la escuela histórica alemana de economía e influenciado probablemente por Nietzche. De acuerdo con estos autores, Nietzche entendía la creación y la destrucción como elementos inseparables en un proceso, artístico o de otro tipo, de forma que la creación de algo nuevo está intrínsicamente relacionada con la destrucción de lo viejo o de aquellas formas, cosas, ideas u órdenes existentes. De modo que esta idea se filtraría a en Schumpeter vía Sombart, para referirse al tipo de proceso que acomete el emprendedor: las innovaciones inducidas implicaban la destrucción de formas organizativas de negocio, tecnologías, maquinarias y formas de producción más arcaicas. Según Reinert, E.S. (1994), en Schumpeter aparecía una "competencia dinámica imperfecta", la cual ya se había observado en las estrategias de crecimiento de los países industrializados. En este sentido, la ola de innovaciones implicaba un proceso de "destrucción creativa" que se agrupaba en torno a unas pocas actividades emprendedoras y proporcionaba beneficios muy diferentes entre las industrias que se extendían de un modo colusorio. Es decir, las industrias de los países más desarrollados no crecieron basadas en un idealizado mercado libre, de competencia perfecta y equilibrio (elementos centrales del pensamiento neoclásico), sino a través de la formación de monopolios, aplicación de restricciones al comercio y acuerdos políticos que favorecieron las condiciones para un desarrollo tecnológico en los procesos de manufactura. De hecho, desde el punto de vista de Reinert, E.S. (1994), el pensamiento de Schumpeter sobre la evolución económica retaba a la economía ortodoxa neoclásica.

En conjunto, las perspectivas expuestas anteriormente comparten cierto paralelismo: el proceso de "destrucción creativa" asociado a las innovaciones tiene, en general, una connotación positiva dentro de las explicaciones sobre cambio, progreso y evolución económica. La innovación se asocia a la creación de novedad (ya sea en la forma de producción, combinación de materias primas, forma de organizar un negocio, lanzamiento de un nuevo producto, etc.) e implicaba la destrucción de aquella forma de producción, combinación de materias primas, etc., precedente. Asimismo, las innovaciones serían aquellas que traen beneficios económicos extraordinarios para los emprendedores, y éstos tenderían a disminuir a medida que otros imitasen tales innovaciones de forma exitosa. En contraste, el modelo de Christensen basado en la innovación disruptiva insta a la innovación (tecnológica, barata y de baja calidad) y está cargado de promesas optimistas sobre beneficios económicos, pero la introducción de innovación (tecnológica) no implica éxito per se. De hecho, como la innovación y la creación de novedad ocurre permanece sin responder (Fagerberg, 2003: 30). El modelo contiene además mensajes de pánico sobre la quiebra y extinción empresarial (o innovas o desapareces del mercado) (Lepore, 2014).

Recapitulando, a partir principalmente de la década de los 60, la innovación va a ser crecientemente redefinida en diversos campos académicos y enfoques que se encuentran a veces muy interrelacionados. A groso modo, la innovación es redefinida y estudiada en diferentes niveles de análisis: a nivel individual (usualmente asociado al "emprendedor individual"), a nivel de la pequeña y mediana empresa, a nivel de la gran empresa y también a nivel institucional. En este último caso, la innovación es vista más desde una perspectiva sistémica, como un proceso, de modo que el análisis se centra más en estudiar las interacciones entre distintas instituciones públicas y privadas (empresas pequeñas, medianas y grandes, sectores educativos, administraciones públicas y gobiernos, universidades etc.) y los factores sociales que favorecen u obstaculizan el proceso de la innovación. A su vez, elementos tales como "aprender al hacer" pueden observarse tanto en el nivel de la empresa como en el nivel institucional en el que se ha redefinido la innovación. Tales análisis y redefiniciones se nutren de una extendida connotación positiva del término, en contraste con la connotación negativa que presentaba antes del siglo XX (Godin, 2014b). Por tanto, no podemos hablar de un concepto de innovación como tal, sino de múltiples y diferentes redefiniciones que se sostienen colectivamente y continúan rehaciéndose. De hecho, la propia naturaleza indeterminada del concepto es la que podría permitir que se propague a lo largo de diferentes disciplinas académicas y diferentes enfoques, dentro de tales disciplinas.

3.3 La movilización de la innovación en el plano político europeo

Diferentes visiones y construcciones conceptuales de la innovación procedentes de la literatura académica van a converger simultáneamente y, gradualmente, en el contexto político europeo. Por ejemplo, los estudios de los "sistemas de innovación" ganaron creciente atención en la agenda política europea desde finales del siglo XX (ver por ejemplo Fagerberg, Guerrieri y Verspagen, 2000). Asimismo, algunas visiones de la innovación asociadas con la noción de economía del conocimiento popularizadas en la década de los 90 a través de la OCDE, también se han movilizado en discursos políticos europeos tales como la Agenda de Lisboa (Consejo Europeo, 2000). Concretamente, el Consejo Europeo de Lisboa marcó el objetivo de convertir la economía de la Unión Europea en "la economía del conocimiento más competitiva y dinámica del mundo, antes del 2010" (Consejo Europeo, 2000). Además, este discurso también ha sido criticado por invocar la visión del modelo lineal de innovación (Laurent, 2016). Godin (2006a) señala que el modelo se ha seguido usando porque da un sentido de orientación en cuanto a la asignación de fondos en Investigación y Desarrollo, aun cuando se menciona el carácter ficcional de la linealidad del modelo en los mismos documentos en los que se usa.

La estrategia política sucesora de la Agenda de Lisboa ‒ la Estrategia Europa 2020 (European Commission, 2010a) ‒ también moviliza a la innovación en varios retos simultáneos: subsanar y corregir los defectos de su estrategia antecesora, aliviar los impactos de la crisis financiera de 2007-2008 y lidiar con problemas sociales y medioambientales. Cómo veremos en el capítulo 2 en el que analizamos críticamente esta estrategia, la innovación es (re)invocada a través de un conjunto no lineal y más complejo de interacciones entre elementos tales como la investigación básica y aplicada, empresas de negocios, industrias y sectores académicos. La estrategia EU2020 incluyó además varias iniciativas emblemáticas como "La Unión de la Innovación" (European

Commission, 2010c). Particularmente, esta iniciativa estableció un objetivo tripe en el que la innovación se asemejaba más a un *proceso*:

> 1) convertir a Europa en un actor científico de clase mundial, 2) revolucionar la forma en que los sectores público y privado trabajan juntos, especialmente a través de consorcios de Innovación, y 3) eliminar obstáculos como las patentes costosas, la fragmentación del mercado, la lentitud en el establecimiento de normas y la escasez de habilidades, que actualmente impiden que las ideas lleguen rápidamente al mercado [make Europe into a world-class science performer; (2) revolutionize the way public and private sectors work together, notably through Innovation Partnerships and (3) remove obstacles - like expensive patenting, market fragmentation, slow standard-setting and skills shortages – that currently prevent ideas getting quickly to market] (European Commission,, 2010c).

Una similar visión de la innovación como proceso puede observarse en muchos proyectos de investigación financiados bajo el llamado "Horizonte 2020", que trata de implementar la iniciativa de la "Unión de la Innovación" (European Commission, 2013). En este sentido, los proyectos tratan la dimensión social e institucional de la innovación, investigando las instituciones (públicas y privadas) requeridas para favorecer la innovación y promoviendo más participación ciudadana (ver por ejemplo el proyecto "SIMPATIC" en Cordis, 2016). De igual manera, el enfoque analítico de la innovación a nivel de empresa, puede observarse en muchos proyectos que incluyen una participación extensiva de pequeñas y medianas empresas (PYME) para mejorar las estrategias comerciales de estos "sectores de la innovación" (ver por ejemplo el proyecto "LCA TO GO" en Cordis, 2014). Este enfoque a nivel de empresa puede también observarse en el programa sucesor de Horizonte 2020: "Horizonte Europa". En este último, que cubre el periodo 2021-2027, se anuncia la introducción del llamando "Consejo de Innovación Europeo" para apoyar principalmente a las pequeñas y medianas empresas en el desarrollo de innovaciones de naturaleza disruptiva que podrían tener alto riesgo (European Commission, 2021b). Este tipo de naturaleza "disruptiva" es resonante con el modelo promovido por Christensen (1997), citado por Lepore (2014).

Paralelamente, la innovación es crecientemente invocada en políticas como la Economía Circular (European Commission, 2015), o enfoques recientes orientados a transformaciones sociotécnicas a gran escala tales como la Cuarta Revolución Industrial (European Commission, 2016) o el Pacto Verde Europeo (European Commission, 2019b). En el caso de la política de la Economía Circular, las innovaciones son introducidas principalmente como objetos y procesos técnicos, que suelen asociarse a un resultado de investigación y desarrollo (I+D) tanto desde el ámbito privado como público. En el capítulo 3, exploramos esta cuestión con más detalle a través del análisis crítico de catorce innovaciones que han sido seleccionadas por la Comisión Europea como "conductoras" de la economía circular. En conjunto, en esta política y en enfoques más recientes, la innovación penetra en un amplio rango de dominios políticos y sectoriales y es crecientemente reivindicada como una "solución" prometedora a muchos de los problemas acuciantes de nuestra época. Por tanto, la innovación, entendida como *imaginario* que se (re)construye de forma colectiva, permite la colaboración entre dominios políticos y sectoriales (empresarial, industrial, de la ingeniería, etc.) y compartir significados de articulaciones de problemas comunes como el cambio climático, incluso aunque existan significados distintos dentro de tales dominios (Pfotenhauer y Jasanoff, 2017). La innovación permite además compartir significados de posibles "soluciones" a tales problemas y futuros deseables (Taylor, 2002). Tales significados sostenidos colectivamente configuran las agendas políticas y dan forma a las políticas, las cuales tienen, necesariamente, consecuencias en el mundo material a través de prioridades de investigación e intervención y prácticas (Law, 2004). De hecho, ante este tipo de construcción colectivo de significado, criticar a la innovación como objeto académico por su falta de consenso o rigor científico no parece tener mucha importancia. La propia naturaleza indeterminada del concepto, posibilitaría que se propague simultáneamente a largo de distintas disciplinas académicas, dominios sectoriales y políticos y escalas de gobernanza (ej. regional, nacional, europea).

3.4 La innovación en nuestra investigación

En la investigación, consideramos a la innovación como un imaginario sociotécnico que es co-creado históricamente a través de un trabajo científico, técnico y político que se encuentra entrelazado, implicando una coproducción simultánea de órdenes sociales, técnicos y científicos (Jasanoff y Kim, 2009, 2015) *(*Pfotenhauer y Jasanoff, 2017). En este sentido, los imaginarios sociotécnicos de la innovación son co-creados dentro de ciertas comunidades científico-técnicas y políticas y se convierten en prioridades políticas con consecuencias en el mundo material. Es decir, los imaginarios pueden usarse como fuente para planes de acción y las "soluciones" tecnocientíficas visionadas se pueden intentar materializar.

Sin embargo, en nuestra disertación, y particularmente en los estudios de caso desarrollados en el capítulo 2 y 3 respectivamente, **no** investigamos los procesos a través de los cuales tales imaginarios de la innovación se co-crean y llegan a ser prioridades de investigación dentro de una política concreta, y, finalmente, se convierten en objetos materiales. Nuestro propósito es más específico. A través de los dos primeros objetivos específicos, y especialmente a través del segundo objetivo, investigamos el papel de la innovación (como imaginario construido colectivamente) al interaccionar y relacionarse con el nexus. Es decir, por un lado, hay una necesidad de entender y profundizar por un lado en las razones, los mecanismos y las funciones de movilizar e introducir las innovaciones como ideas e imaginarios en las políticas del nexus, es decir, como un medio de reconocer los tradeoffs entre diferentes áreas políticas del nexus. Por otro lado, exploramos como aquellas innovaciones, una vez proyectadas e introducidas, interactúan con el nexus. En este último sentido, exploramos las implicaciones potenciales de las innovaciones *para* la gobernanza del nexus. En conjunto, investigar estas relaciones entre innovación (como imaginario e idea) y el nexus nos permitirá entender mejor como recientes políticas europeas podrían, en parte, (re)adquirir significado en una situación de crisis de legitimidad del proyecto europeo.

En la siguiente sección 4, introducimos de forma más detallada el pensamiento del nexus.

4. El pensamiento del nexus

En esta sección realizamos una introducción más detalle sobre el pensamiento del nexus. Concretamente, en la primera subsección realizamos una breve revisión literaria sobre el pensamiento del nexus. En la subsección 4.2, introducimos el punto de vista de varios analistas sobre el nexus para precisar las relaciones entre el "nexus" y el papel de la innovación (como imaginario) que se investigan a través de los dos primeros estudios de caso. En la última subsección (4.3), introducimos una especificidad del pensamiento del nexus, a saber, su tensión dicotómica entre lo global y lo local, y señalamos su relación con nuestra investigación.

4.1 Breve revisión literaria sobre el pensamiento del nexus

La palabra "nexus" ha ido ganando creciente atención en los últimos años, tanto en la literatura científica-académica como en el contexto político. Por mencionar un detalle, si buscamos la palabra "water-energy-food nexus" en la herramienta de búsqueda de Google obtenemos más de 16,4 millones de registros a fecha de 27 de febrero de 2021, comparados con aquellos 53.000 registros aproximados que se obtuvieron en junio de 2014 (Endo et al., 2017: 2). De acuerdo con Endo et al., (2017), la investigación del nexus aparece fragmentada y no hay un concepto claro ni único. Por el contrario, existen múltiples interpretaciones desde diferentes disciplinas, contextos e incluso regiones (Ringler et al., 2013). En lo que sigue, revisitamos dos principales usos de la palabra "nexus" que pueden distinguirse en la literatura existente y se encuentran interrelacionados.

A groso modo, la palabra "nexus" puede ser usada tanto para la interconexión biofísica entre agua, energía y alimentación como para el reto de gobernanza y formulación de políticas coherentes, integradas y coordinadas sobre estas tres principales áreas o seguridades del nexus (Bazilian et al., 2011; Harwood, 2018; Pahl-Wostl, 2019; Khan et al., 2017; Giampietro et al., 2017). En la literatura científica, el nexus biofísico se ha interpretado desde el campo de la Ecología, y particularmente, desde las teorías de la complejidad (Holling, 2001; Holling and Gunderson, 2002; Odum, 1983; Ulanowicz, 1995). De estas perspectivas, cuando se enfatizan las interconexiones entre el agua, la energía y la alimentación, se pone énfasis en la indivisibilidad, resiliencia y complejidad de los sistemas socio-ecológicos (Giampietro et al., 2017). A su vez, debido a la inherente complejidad de los sistemas, uno podría tener varios problemas emergiendo a lo largo de los sistemas y dominios. Además, dado que los sistemas no son lineales, las "soluciones" podrían llevar a diferentes resultados en distintas escalas. En este sentido el nexus se considera un enfoque *orientado a señalar problemas y tradeoffs* e implicaría hablar, por ejemplo, de los tradeoffs y tensiones interconectadas entre la agricultura, el uso del agua, la producción de energía y las prácticas de consumo.

En el campo de la economía ecológica, el nexus biofisico también se ha interpretado por su estrecha relación con los conceptos de economía circular y bioeconomía (Giampietro, 2019). En palabras de Giampietro: "Una (bio)economía circular implica la capacidad para estabilizar en el tiempo el reciclaje de la mezcla de nutrientes y agua requerida para la provisión renovable de biomasa para la seguridad energética y alimentaria de un modo coordinado" [A circular (bio)economy implies the ability to stabilize in time the recycling of the mix of nutrients and water required for a renewable supply of biomass for food and energy security in a coordinated way] (Giampietro, 2019:153). Desde esta perspectiva, el nexus estaría relacionado con unas interconexiones biofísicas entre agua, energía y alimentación que permitiesen estabilizar el funcionamiento de los sistemas socio-ecológicos. Dicho de otra manera, hablar del nexus implica hablar de: a) que el metabolismo del agua, energía y alimentación depende de la disponibilidad de las llamadas fuentes primarias y sumideros primarios de la biosfera, y b) la necesidad de una compatibilidad entre el tamaño de los flujos primarios requeridos por los procesos económicos en la tecnosfera y el ritmo y la densidad asociada a los procesos ecológicos en la biosfera (Giampietro, 2019).

Asimismo, hablar del nexus (biofísico) también implica advertir sobre los *límites* del crecimiento económico impuestos por la naturaleza. Estas advertencias han sido objeto de debate académico y político al menos desde los tiempos de Malthus a finales del siglo SXVIII (Giampietro et al., 2012) y retomaron creciente atención desde mediados del siglo pasado, a través de obras como la de Carson (1962) o el informe sobre "Los límites al crecimiento" (Meadows et al., 1972). Pensar en el nexus (biofísico) también implica hablar de las tensiones entre el crecimiento económico, la sostenibilidad y la necesidad de respetar la integridad de los ciclos naturales de forma que los recursos biofísicos puedan renovarse y regenerarse (Giampietro et al., 2014; Rasul, 2016), Desde esta perspectiva, se ha argumentado que los retos epistemológicos de comprender las interconexiones biofísicas, necesitan ser abordados junto a los problemas políticos de gobernar una transición hacia modos de producción y consumo más sostenibles (Giampietro et al., 2017). En este sentido, el nexus es también entendido como un *problema de gobernanza (*Voelker et al., 2019**).**

El nexus de la gobernanza supondría a su vez cambios sustantivos en los procesos dominantes de gobernanza, como retar la tradicional división institucional de competencias en la que diferentes ministerios (o direcciones generales en el caso de la Comisión Europea) se encargan de diferentes políticas. En el caso de la Comisión Europea, su organización en 34 direcciones generales (DGs-Departamentos) (European Commission, 2021a) ha sugerido la idea de "silos de política" (Turnpenny et al., 2008), de forma que el nexus de la gobernanza implicaría retar este enfoque y propiciar colaboraciones coordinadas para tratar cuestiones que atraviesan el dominio de múltiples direcciones generales. Por ejemplo, los bio-combustibles podrían ser gobernados simultáneamente por la política energética y la política de la agricultura. Sin embargo, las cuestiones del nexus también podrían conducir a que diferentes direcciones generales (o instituciones) abordasen la misma cuestión y podrían generarse conflictos debido, por ejemplo, a la aplicación de enfoques diferentes. También podría producirse un vacío político en la propia cuestión a abordar, al asumirse que el asunto sería abordado por otra institución cuando realmente no lo hace

Asimismo, el pensamiento del nexus podría usarse para reflexionar a nivel de sistema de la gobernanza medioambiental. Desde el punto de vista de la complejidad, el nexus permite abrir una discusión de tradeoffs y paradojas que surgen de cómo sistemas complejos como un todo se adaptan a cambios en las partes o cómo se podría influenciar la identidad de un sistema como un todo. En este sentido, el pensamiento del nexus es precaucionario es sus prescripciones de gobernanza, ya que señala la existencia de pros y contras en cada acción y no se producen claras recomendaciones sobre qué hacer. Dicho de otra manera, el nexus hace referencia a los **límites de la gobern-abilidad.**

En cuanto a la distinción entre nexus biofísico y nexus de la gobernanza, para algunos académicos el reto del nexus de la gobernanza radica en que las interconexiones biofísicas de "ahí fuera" no pueden comprenderse totalmente (Giampietro et al., 2017, 2018). De hecho, este es uno de los puntos claves de las teorías de los sistemas complejos. Para otros académicos, esta distinción implicaría una comprensión eventual de estas interconexiones, es decir, que la complejidad del nexus (biofísico) puede llegar a clarificarse eventualmente. El siguiente texto es bastante ilustrativo en esta cuestión: "[…]las relaciones de los tres recursos tales como agua-energía, agua-alimentación y/o el agua-la alimentación-energía están interrelacionadas y son interdependientes, lo que implica que la *complejidad del sistema del nexus no ha sido todavía clarificada*" [the relationships of all three resources such as water–energy, water–food and/or water–energy–food are interrelated and interdependent, which implies that the complexity of the nexus system has not yet been clarified] (Endo et al., 2017: 2).[5]

En la siguiente subsección y siguiendo esta distinción entre nexus biofísico y nexus de la gobernanza, introducimos el punto de vista crítico de varios analistas sobre la gobernanza del nexus.

4.2 La Gobernanza tecnocrática del nexus

A través de la existente literatura se aprecia que la discusión del nexus se centra extensivamente en cuantificar y visibilizar interconexiones y tradeoffs del nexus (biofísico) (Mustaq et al., 2019; Siddiqi y Anadon. 2011; Cabelllo et al., 2019, Endo et al., 2017). En menor medida, varios analistas han empezado a abordar los aspectos y mecanismos institucionales, políticos y culturales

[5] La cursiva es nuestra.

que dificultan la formulación de políticas de gobernanza del nexus y, de hecho, la misma implementación del pensamiento del nexus (Cairns y Krzywoszynska, 2016; Howarth y Monasterolo, 2016; Leese y Meisch, 2015; Stirling, 2015; Voelker et al., 2019). A groso modo, estos analistas argumentan que la gobernanza del nexus es susceptible de una gobernanza tecnocrática, de forma que la interpretación del nexus en el contexto político está sujeta a "soluciones" técnicas, "silver bullets" y enfoques tecnocráticos de gestión medioambiental.

Específicamente, Stirling (2015) argumenta que las ideas que promueven "soluciones" técnicas para unas interconexiones complejas e intensamente interrelacionadas son simplificaciones instrumentales. Y estas simplificaciones hacen posible definir un objeto de gobernanza y un modo de gobernar que podemos referir como "gobernanza *de* la complejidad". Por su parte, Cairns and Krzywoszynska (2016) señalan que la interpretación del nexus se ha centrado en imaginarios idealizados que integran objetivos contrapuestos (ej. crecimiento económico y el uso sostenible de recursos naturales), lógicas basadas en "soluciones que benefician a todas las partes" y lemas de eficiencia. Y tales lógicas están oscureciendo los resultados insostenibles de las prácticas políticas y económicas. Desde este punto de vista, el nexus debería ser mantenido como una "cuestión de preocupación" [matter of concern] y no de "hecho" [matter of fact] (Cairns and Krzywoszynska, 2016: 165). De forma algo similar, Leese and Meish (2015) analizan críticamente cómo se aborda la cuestión del nexus en la conferencia celebrada en la ciudad alemana de Bonn en 2011, a partir de la cual el término "nexus" adquirió mayor popularidad en el contexto político europeo (Kovacic et al., 2019). Los investigadores argumentan que: a) "el nexus es concebido como algo que es muy manejable, incluso si los límites planetarios han sido ya cruzados" (Leese and Meish, 2015: 704), y b) que el conocimiento del nexus se usa como mecanismo estratégico para fomentar crecimiento económico y políticas neoliberales bajo el lema de "economía verde" dejando las necesidades de los más pobres en un segundo plano.

Siguiendo la línea de estos autores, el término "nexus" permite: a) abrir la posibilidad de formar alianzas público-privadas, es decir, entre comunidades que gobiernan y empresas privadas de negocios y sectores industriales, y b) cambiar el lenguaje de una discusión de tradeoffs y límites por un discurso basado en la creación de "oportunidades" y "soluciones que benefician a todas las partes". De hecho, ésta es precisamente **una** de las relaciones entre el nexus y el papel de la innovación (como imaginario) que abordamos en la investigación, pero no la única. A continuación, especificamos las relaciones entre "innovación" y el "nexus" que investigamos en los dos primeros estudios de caso:

a) En el primer estudio de caso, analizamos críticamente el discurso político de la estrategia EU2020 (European Commission, 2010a), en el cual la innovación se proyecta como prometedora "solución" tanto para los problemas económicos como para los medioambientales y sociales. Particularmente, el crecimiento económico y la sostenibilidad no son anunciados en conflicto y tensión, sino reconciliados y mutuamente beneficiados. De hecho, la necesidad de un discurso anunciado en términos positivos puede derivarse, en buena medida, de la necesidad de recuperación de la crisis financiera de 2008-2009. En este análisis crítico se explora el papel que juega el imaginario de la innovación *en* la gobernanza del nexus, es decir, cómo la innovación podría conducir el pensamiento del nexus y la discusión de tradeoffs y límites hacia la formulación de un discurso tecnocrático de "soluciones que benefician a todas las partes". En este sentido, es interesante señalar que antes de la conferencia de Bonn en 2011, el término "nexus" había empezado a tomar cierta popularidad en el contexto político europeo con la celebración del "World Economic Forum" de 2008, del cual se derivaron publicaciones que también anunciaban una reconciliación del crecimiento económico con las restricciones medioambientales (World Economic Forum, 2011: 13). Por otro lado, en nuestro análisis se explora críticamente las implicaciones del discurso idealizado de la innovación para i) algunos aspectos sociales relacionados con la desigualdad y el bienestar humano *y ii)* la gobernanza del nexus (ej. tensiones potenciales en otras partes del nexus). Ésta última es precisamente **otra** de las principales relaciones entre el papel de la innovación como imaginario y el nexus que abordamos en la investigación. En este sentido, nuestro análisis crítico se asemeja al realizado por Cairns y Krzywoszynska (2016), quienes señalan cómo las políticas del nexus que anuncian "soluciones mutuamente beneficiosas" oscurecen prácticas insostenibles. Similarmente, nuestro análisis también se asemeja al realizado por Leese y Meish (2015), quienes critican las políticas que anuncian el lema de "economía verde" por su carácter neoliberal y por desatender las necesidades de los más pobres. Sin embargo, nuestro análisis "crítico" tiene un propósito más bien didáctico que se inscribe dentro de la primera pregunta de investigación planteada: ¿sí y de qué modo las políticas europeas podrían estar (re) adquiriendo significado al interaccionar con perspectivas críticas que destacan tradeoffs del nexus y daños infligidos socialmente? Esta cuestión será abordada de forma más específica en la sección 1 del capítulo 5, donde reflexionamos de manera "post-hoc" sobre las lecciones aprendidas a través de los dos primeros estudios de caso.

b) En el segundo estudio de caso, tratamos de desarrollar una mayor comprensión del papel que está jugando el imaginario de la innovación *en* (y *para*) la gobernanza medioambiental del nexus biofísico en la política europea de la Economía Circular (European Commission, 2015). La política de la Economía Circular también anuncia una reconciliación entre los objetivos del crecimiento económico y la sostenibilidad vía innovación. Asimismo, esta política se formula en una situación donde la crisis de legitimidad del proyecto europeo se agudiza y el nexus surge de forma más significativa en la escena política europea a raíz de la conferencia de Bonn en el año 2011 (Hoff, H., 2011). Concretamente, en este estudio de caso, investigamos críticamente el papel de los imaginarios de innovación (que han sido seleccionados como "conductores" de la economía circular) en su relación con tradeoffs del nexus y preocupaciones medioambientales (p.ej.

residuos, contaminación atmosférica de CO_2, dependencia en recursos fósiles). En cuanto a la gobernanza *para* el nexus, exploramos potenciales tradeoffs y tensiones con otras partes del nexus (biofísico), en el supuesto de que las innovaciones se implementasen a gran escala. De forma similar al primer estudio de caso, el propósito de este análisis crítico es más bien didáctico, y nos ayudará a responder a la primera pregunta de investigación.

En la última subsección introducimos una especificidad del pensamiento del nexus y su relación con nuestra investigación.

4.3 El pensamiento del nexus en la escala global y local.

Bruno Latour señala una tensión dicotómica entre "lo global" y "lo local" en su último libro (Latour, 2018: 16). Esta tensión hace referencia a que, por un lado, el planeta parece demasiado pequeño para "lo global" y hay una necesidad de "lo local", ya que es aquí donde los problemas se desarrollan, se experimentan y pueden reflexionarse como experiencias vividas. Por otro lado, el planeta parece demasiado grande para permanecer en los límites de cualquier localidad o región, de modo que el planeta figura como el denominador común y el último horizonte de nuestros problemas colectivos. La cuestión del cambio climático representa un claro ejemplo de esta tensión. Por un lado, tenemos problemas experimentados en lo local como consecuencia del cambio climático, y, por otro lado, tenemos la cuestión del cambio climático como un problema colectivo a escala global. A continuación, exploramos como esta tensión impregna al pensamiento del nexus, tanto el biofísico como el de gobernanza. Dicho de otra manera, la discusión de los límites y los tradeoffs se produce simultáneamente en la escala global y subsecuentes escalas (supranacional, nacional, regional o local).

A través de la literatura científica existente puede apreciarse que el pensamiento del nexus (biofísico) se centra extensivamente en cuantificar interconexiones biofísicas, a través de diferentes métodos de valoración y herramientas y en diferentes escalas (ver por ejemplo Granit et al., 2012; Siddiqi y Anadon, 2011; o Cabello et al., 2019; Gulati et al., 2013, Giampietro, et al. 2013). Específicamente, en estas líneas de investigación los tradeoffs y los problemas perversos[6] del nexus tienden a ser reflexionados a escala regional o local porque es donde el problema subsiste. En consecuencia, es en estos niveles "más bajos" donde debería solucionarse, aunque esto no excluye que puedan tener soluciones en niveles "más altos" (ej. europeo). Por ejemplo, en el informe de Cabello et al. (2020) se analiza la desalinización como "solución tecnológica" a un problema (insular) de escasez de agua en la agricultura. El pensamiento del nexus (biofísico) permite abrir una discusión de potencial tradeoffs creados por esta "solución" a nivel local (ej. dependencia en combustibles fósiles ya que la innovación es muy intensiva en energía, la calidad

[6] Término introducido por Rittel y Webber (1973) que comparte cierta semejanza con los tipos de problemas del nexus.

del agua tratada, afección al suelo, etc.). El pensamiento del nexus permite además reflexionar sobre si el problema de escasez de agua a nivel insular es un problema políticamente construido que se deriva, por ejemplo, de una agricultura que está dedicada principalmente a la exportación y requiere altos consumos de agua. En este sentido, se advierten los "límites" de las estrategias productivas orientadas al crecimiento económico y la exportación, y de las tensiones con la sostenibilidad local, poniendo énfasis en la necesidad de otras alternativas más sostenibles que permitan respetar y regenerar los ciclos naturales del agua.

Por otra parte, la cuestión de la gobernanza del nexus a diferentes niveles se ha señalado en la plataforma que se estableció a raíz de la Conferencia del Nexus de Bonn en 2011: "El enfoque del Nexus es un cambio fundamental, desde un enfoque sectorial puro a soluciones que abarcan una perspectiva integrada, coherente e intersectorial. El enfoque reta estructuras existentes, políticas y procedimientos en los niveles globales, regionales y subnacionales" [The Nexus approach is a fundamental shift, from a pure sectoral approach to solutions that embrace a cross-sectoral, coherent and integrated perspective. It challenges existing structures, policies and procedures at global, regional and (sub) national levels.] (Nexus Resource Platform, 2015). Está fuera del alcance de esta investigación explorar si estos esfuerzos por gobernar el nexus a diferentes niveles son susceptibles de una gobernanza tecnocrática en el sentido propuesto por Cairns y Krzywoszynska (2016), Stirling (2015) o Voelker et al. (2019). Nuestro propósito en esta subsección es ilustrar como el pensamiento del nexus, tanto el biofísico como el de gobernanza, se mueve simultáneamente entre la escala global y subsecuentes escalas (nacional, regional o local). Este comentario también se aplica a los siguientes esfuerzos de la Ciencia del Sistema de la Tierra (Earth System Science Partnership, 2015) por gobernar el nexus biofísico en la escala global. En esta disciplina, el planeta (también llamado globo o Gaia) es considerado un sistema complejo, dinámico e integrado en el que interaccionan, a través de flujos de materiales y energía, diversas esferas (atmósfera, hidrosfera, biosfera, etc.), subsistemas y sociedades humanas. El planeta es, además, considerado el denominador común para advertir las tensiones entre las actividades económicas y la sostenibilidad global, y es notable el esfuerzo por cuantificar y predecir el impacto de tales actividades en los cambios medioambientales globales. A su vez, la Ciencia del Sistema de la Tierra es el pilar fundamental de otra plataforma de investigación que aborda el nexus de la gobernanza a escala global, a saber; Future Earth (Future Earth, 2013a). En su web puede leerse: "Al comprender las conexiones entre los sistemas ambientales, sociales y económicos, Future Earth trabaja para facilitar la investigación y la innovación, construir y movilizar redes y dar forma a la narrativa, convirtiendo el conocimiento en acción" [By understanding connections among environmental, social and economic systems, Future Earth works to facilitate research and innovation, build and mobilize networks and shape the narrative, turning knowledge into action] (Future Earth, 2013b).

En conjunto, esta especificidad del pensamiento del nexus (biofísico y de la gobernanza) que se mueve simultáneamente entre distintas escalas, tiene implicaciones para las relaciones entre la “innovación” y el “nexus” que se investigan en esta disertación. Concretamente reflexionaremos sobre cómo los imaginarios de innovación, una vez introducidos en las políticas podrían también discutirse y ser objeto de críticas desde el punto de vista del pensamiento del nexus en las escalas locales o regionales. Reflexionaremos sobre esta cuestión en la sección 5.1 del capítulo 5, donde conectamos los resultados de los dos primeros estudios de caso e introducimos además un principio que es intrínseco al propio proyecto europeo: el principio de subsidiariedad.

Asimismo, en el tercero estudio de caso encontramos un implícito paralelismo entre i) la discusión de la “innovación” desde el punto de vista de los tradeoffs *para* el nexus en las escales locales y ii) una postura crítica que revisamos en el tercer estudio de caso. A continuación, explicamos este paralelismo:

En el tercer estudio de caso, analizamos críticamente unas narrativas emergentes en la web social IFLS ante la elección de Trump como presidente de Estados Unidos en 2016. Concretamente, retamos la principal narrativa conceptualizada que (re) invoca visiones idealizadas de la ciencia del modelo moderno junto a una versión del modelo del déficit público. A groso modo, en esta narrativa se anuncia que el “cambio climático es una cuestión de la ciencia y la ciencia trata sobre la verdad y los hechos, pero ellos no entienden la ciencia del clima”. Para ello, revisamos una postura que crítica el “modelo del déficit público” (i.e. Irwin y Wynne, 1996) con el propósito de explorar implicaciones para el diálogo público sobre la cuestión del cambio climático cuando interactúan: a) la narrativa retada con asumida propensión a invocar “soluciones tecnológicas globales” en la gobernanza del problema del cambio climático, b) críticas hacia dicha narrativa basadas en la postura de Irwin y Wynne (1996), y c) aquellas voces que representan a “ellos” dentro de la narrativa retada.

Por otra parte, en esta sección hemos indicado que, desde el punto de vista de la complejidad, el pensamiento del nexus permite abrir una discusión de tradeoffs a nivel de sistema de la gobernanza medioambiental. Desde esta perspectiva, el cambio climático puede reflexionarse como problema del nexus a nivel de sistema complejo, interconectado e indivisible, y las “soluciones” podrían llevar a diferentes resultados en escalas distintas y/o a problemas y efectos colaterales inesperados a lo largo de los sistemas, dominios y escalas. También hemos señalado que los tradeoffs del nexus tienden a reflexionarse a escala regional o local, de modo que, por ejemplo, ante la propuesta de una determinada “solución” tecnológica, se podría advertir de una creciente presión en los fondos biofísicos de la biosfera (reconceptualizada desde el concepto de naturaleza, Giampietro, 2019) de una determinada región o localidad.

Si contrastamos este pensamiento con la postura crítica de Irwin y Wynne (1996) observamos que, de forma bastante similar, esta postura crítica también reconoce la condición de complejidad cuando se abordan problemas medioambientales (léase también aquí: problemas sistémicos del nexus). Dicha postura tiende, además a, señalar: a) el fracaso de las técnicas reduccionistas y las "soluciones tecnológicas globales" (léase también aquí: innovación) que se proponen para lidiar con tales problemas complejos y b) el daño colateral que tales técnicas y soluciones infligen y causan a la *naturaleza* o a los seres humanos en la *escala local.* En este sentido, encontramos un implícito paralelismo entre esta postura crítica y el pensamiento del nexus, especialmente en su particular discusión orientada a señalar problemas, tradeoffs y las presiones sobre las fuentes primarias y sumideros primarios de la biosfera (léase también aquí: la naturaleza) que emergen a nivel local.

En la sección 3 del capítulo 5, rescatamos este implícito paralelismo para reflexionar de manera transversal sobre las perspectivas críticas aplicadas en los estudios de caso y sugerir una lección de corte transversal.

5. Enfoques

En esta sección introducimos los enfoques teórico-metodológicos que se aplican para la consecución de los objetivos relacionados con los tres respectivos estudios de caso. Si bien, primero recapitulamos brevemente el modo en el que aplicamos el concepto de imaginario sociotécnico y algunos aspectos metodológicos considerados en los dos primeros estudios de caso.

5.1 El imaginario socio-técnico como herramienta conceptual y la distancia analítica como reto metodológico

En la subsección 3.4, introducimos el concepto de imaginario sociotécnico (Jasanoff and Kim 2009, 2015; Pfotenhauer and Jasanoff, 2017) para aproximarnos a la "innovación" movilizada en las políticas europeas y formas relacionadas de gobernanza del nexus. En este sentido, cuando las innovaciones se movilizan *en* la gobernanza del nexus, tales innovaciones son entendidas primariamente como promesas, visiones, ideas y objetos de imaginación y deseo, bajo una diversidad de formas tales como objetos técnicos, procesos técnicos o prácticas. De modo que los imaginarios de innovación son comprendidos como expresiones y proyecciones colectivas de futuros tecnológicos deseables bajo la expectativa de que, por ejemplo, tal objeto o proceso técnico juegue al menos un papel importante en el manejo de problemas y tradeoffs del nexus. Dichos imaginarios tienen, por tanto, una orientación futurista dentro de los discursos y narrativas políticas en las que se movilizan. Al mismo tiempo, exploramos el papel de estos imaginarios de innovaciones para la gobernanza del nexus. De hecho, los imaginarios de innovación pueden intentar materializarse y llegar a implementarse a través prioridades políticas de investigación y acción. En el segundo estudio de caso, la mayoría de las innovaciones seleccionadas para una economía circular se encuentran en fases de prueba, estudios piloto o experimentación en el laboratorio, y de igual forma exploramos el papel de estas innovaciones para el nexus.

Asimismo, en la sección 1 de este capítulo introductorio y en relación a las políticas europeas basadas en la innovación, introdujimos la necesidad de adoptar cierta distancia analítica en las relaciones que investigamos, es decir, entre el papel de la innovación (como imaginario) y el nexus. Concretamente, tratamos de aplicar una distancia analítica entre la "innovación", el "nexus" y las políticas de gobernanza, conceptualizando sus crecientes intersecciones como un proyecto político (el europeo) que trata de (re)legitimarse en una crisis severa de legitimidad, y no como un desarrollo inevitable. Este reto metodológico será especialmente relevante para la discusión de los resultados de los dos primeros estudios de caso en la sección 5.1 del capítulo 5. Investigar estas intersecciones como elementos constitutivos de la (re)legitimación de un proyecto político, está además en sintonía con uno de los propósitos de los análisis situacionales: poner de manifiesto que las cosas siempre pueden ser de otra manera, no sólo individualmente, sino también colectivamente e institucionalmente (Clarke, 2005:557).

5.2 Enfoques teóricos y metodológicos

En esta subsección introducimos las diversas metodologías y enfoques teóricos aplicados en los análisis críticos de los tres respectivos estudios de caso, e incidimos además en el carácter didáctico de estos análisis en relación con las preguntas de investigación planteadas en la sección 2.

i. *Estudio de caso: "Which roles can innovation play in the idealized socio-technical future announced in the EU2020 strategy?"*

El discurso idealizado de la estrategia Europa 2020 (European Commission, 2010a) se formula en el año 2010 para la recuperación económica de la crisis financiera de 2007-2008, y anuncia una reconciliación del crecimiento económico con las cuestiones medioambientales y sociales a través de la innovación. El objetivo específico en este estudio de caso es analizar críticamente el papel de las innovaciones (como imaginarios) **en** la gobernanza del nexus, de forma que estas relaciones (entre innovación y el nexus) permiten que dicho discurso adquiera parte de su significado en una situación de crisis de legitimidad del proyecto europeo. Asimismo, analizamos críticamente las implicaciones del discurso idealizado de la innovación **para** la gobernanza del nexus, y algunos aspectos como la desigualdad y el bienestar humano.

Para abordar este objetivo, partimos de la tradición de análisis discursivo que se origina en Michael Foucault (2008) y varios de sus intérpretes (Ahlqvist, 2015; Cotoi, 2011; Lemke, 2001, 2002). El propósito general de los análisis Foucaultianos, tanto sobre el crimen, la sexualidad, la locura, la salud o la política económica, es entender como discursos (y prácticas) se forman y llegar a existir, llevando a cabo cierta distancia epistemológica a lo largo del tiempo histórico (Faubion, 2000) (Gale, 2001). En el contexto más específico de los discursos políticos, Foucault (2008) ha señalado como ciertos discursos fundacionales del proyecto europeo – a saber, el Tratado de Roma de 1957 y las ideas sobre la creación de un mercado común competitivo – forman parte de una racionalidad política ordoliberal, que se encuentra muy entrelazada con la cuestión del liberalismo desde mediados del siglo XVIII. Dicha racionalidad está caracterizada por la articulación de un tipo particular de pensamiento económico y un conjunto de prácticas, intervenciones gubernamentales y reglas. Numerosos estudiosos de Foucault tales como Barry (1993) y Barry y Walters (2003), han analizado los relanzamientos del mercado único europeo y la "integración del mercado" a finales de los ochenta, bajo las lentes analíticas de esta racionalidad política ordoliberal. Desde de estas perspectivas, el Tratado de Maastricht de 1992 (European Communities, 1992) y la creación de una Unión económica y monetaria a lo largo de la década de los noventa (European Central Bank, 2022) pueden entenderse como subsecuentes intentos de una “mayor integración del mercado”.

En este estudio de caso, analizamos el discurso de la estrategia EU2020 basado en la innovación como una forma de racionalidad política inspirada en la del ordoliberalismo, orientada a expandir y desarrollar un mercado interno. Dicho mercado es además relativamente reciente si lo comparamos con el de Estados Unidos. Concretamente**,** analizamos críticamente el papel que juega la innovación al interaccionar con el nexus en la formulación de un discurso político que trata de *seguir haciendo* el mercado interno y (re)legitimar el proyecto europeo en una situación de crisis de legitimidad (Kovacic et al 2019). Al mismo tiempo, el análisis del discurso de la EU2020 como una forma de racionalidad política nos permite discutir qué tipo de prácticas e intervención podría ejercer este discurso, particularmente, en términos de implicaciones para el nexus y algunas cuestione sociales.

Por razones didácticas, en el Capítulo 2 que aborda este estudio de caso introducimos primero una visión general sobre las especificidades de una racionalidad política ordoliberal. Concretamente, realizamos un breve recorrido sobre el análisis que Foucault realiza sobre la evolución histórica de esta racionalidad política (conocida también como el “arte liberal del gobierno”) desde mediados del siglo XVIII hasta después de la Segunda Guerra Mundial. Los análisis Foucaultianos suelen llevar a cabo cierta distancia epistemológica en el tiempo, de modo que cuando introducimos su análisis hemos enriquecido esta distancia con una posición teórica más cercana a tradiciones heterodoxas en historia económica y la economía del desarrollo (Chang, 2004, Reinert, 2006, 2017). Posteriormente, y basándonos en la herramienta conceptual del imaginario sociotécnico, conceptualizamos el discurso idealizado de la EU2020 sobre un “crecimiento inteligente, sostenible e inclusivo”, prestando atención a los imaginarios de innovación que son proyectados como futuros deseables.

En la tercera parte del capítulo, aplicamos las lentes teóricas introducidas previamente para investigar críticamente: a) cómo el discurso de “un crecimiento sostenible” se crea a través del papel de la innovación (como imaginario) al relacionarse con problemas y tradeoffs del nexus, y, b) qué tipo de implicaciones ejerce el discurso para el nexus y la sostenibilidad medioambiental. En esta parte analítica hemos aplicado esa distancia epistemológica que se requiere en los análisis Foucaultianos a través de recursos intelectuales de los estudios críticos sobre la innovación (Godin, 2006, 2013) y de la ciencia post-normal (Strand, 2013) (Benessia and Funtowicz, 2015, 2016). Por otro lado, comparamos el discurso y práctica “social” que implica una racionalidad política ordoliberal con el tipo de práctica e intervención que podría ejercer el discurso de la estrategia EU2020, en relación a ciertos aspectos sociales del bienestar humano y la desigualdad.

En conjunto, este análisis "crítico" es concebido como un ejercicio didáctico, sobre el que reflexionaremos de forma conjunta con las lecciones aprendidas en el segundo estudio de caso, para responder a la primera pregunta de investigación (sección 1 del capítulo 5).

ii. Estudio de caso: "The roles of the innovations in (for) the nexus governance through the study of the European circular economy policy"

La política de la Economía Circular (European Commission, 2015) anuncia favorecer la recuperación de la crisis económica de 2007-2008 y conciliar el crecimiento con las cuestiones medioambientales vía innovación (s). El objetivo específico en este estudio de caso es profundizar críticamente en el papel que las innovaciones (como imaginarios e ideas) juegan en la gobernanza del nexus, de forma que las intersecciones entre "innovación" y la discusión de tradeoffs permiten que el discurso y la política adquieran su significado. Asimismo, exploraremos el papel que juegan dichas innovaciones **para** la gobernanza del nexus.

Para la consecución de este objetivo valoramos críticamente y sistemáticamente catorce innovaciones, que han sido seleccionadas por la Comisión Europea como si estuvieran impulsando una "economía circular" (European Commission, 2017) a través dos enfoques teóricos. Por un lado, aplicamos el enfoque taxonómico propuesto por Allenby y Sarewitz (2013). A groso modo, Allenby y Sarewitz distinguen tres niveles de tecnología que implican a su vez objetivos distintos en el uso de una tecnología: a) Nivel I: es la solución tecnológica en sí misma, siendo bastante efectiva en conseguir un efecto deseado, b) Nivel II: se refiere a las infraestructuras socio-técnicas, la legislación, los trabajadores, los sistemas de transporte, etc., necesarios para que la tecnología pueda funcionar e implementarse a gran escala y c) Nivel III: es el nivel en el cual Nivel I a través de Nivel II interactúan con otros sistemas y afectan a los procesos socio-biofísicos y ecológicos en modos impredecibles. En este sentido, el Nivel III puede entenderse como la perspectiva sistémica que permite alertar de los efectos impredecibles que podrían surgir el largo plazo, la incertidumbre que emerge a medida que el sistema se adapta a la innovación desarrollada a gran a escala y la complejidad que caracteriza al sistema. Hemos establecido además un paralelismo entre este Nivel III y el pensamiento del nexus que i) se usa para reflexionar al nivel de sistema de gobernanza medioambiental y ii) permite abrir una discusión de tradeoffs sobre cómo sistemas complejos como un todo se adaptan a cambios en las partes. Por tanto, evaluamos de forma iterativa si y cómo los Niveles I, II y III son tenidos en cuenta en las catorce innovaciones seleccionadas, considerando el objetivo que se espera alcanzar con la innovación y el nivel (I, II o III) en el que efectivamente se enmarca la innovación. Este ejercicio analítico nos ayudará a entender mejor cómo la innovación se moviliza bajo una *diversidad* de formas, y cuáles son mecanismos y las razones de introducir las innovaciones (primariamente como imaginarios) **en** la gobernanza de problemas sistémicos que pertenecen al Nivel III (ej. cambio climático), es decir, en la gobernanza del nexus. Asimismo, este ejercicio analítico nos permitirá reflexionar sobre implicaciones de estas innovaciones **para** la gobernanza del nexus a nivel de sistema.

Este enfoque taxonómico es complementado con una perspectiva teórica que tiende a señalar nexus tradeoffs y tensiones entre crecimiento económico y sostenibilidad. Concretamente, aplicamos conocimientos de la Economía Ecológica (Giampietro, 2019) para discutir algunas potenciales implicaciones para la gobernanza del nexus y la sostenibilidad a largo plazo de las catorce innovaciones seleccionadas en la política de la economía circular. Una buena parte de estas innovaciones tiene como objetivo reciclar, valorizar, convertir, etc. residuos y contaminantes en flujos que puedan ser reinsertados en los procesos económicos. Esta categoría de flujos se ha distinguido en los estudios de los sistemas socio-ecológicos como flujos terciarios (Giampietro, 2019:159). En este estudio de caso, discutimos algunas implicaciones potenciales de estas "innovaciones del reciclaje" en el sentido biofísico, es decir, en términos de tradeoffs y tensiones potenciales para el nexus (biofísico). Dicho análisis es efectuado en un nivel analítico de perspectiva sistémica similar al Nivel III de tecnología propuesto por Allenby y Sarewitz (2013). Es importante incidir que este ejercicio analítico *no* es llevado a cabo con la finalidad de mostrar y visibilizar la potencial falta de viabilidad y factibilidad biofísica para el nexus. El propósito es reflexionar sobre el papel de las innovaciones (introducidas primariamente como ideas e imaginarios) *para* el nexus y cómo la política de la economía circular podría (re)formular su significado al interaccionar, paradójicamente, con las perspectivas sistémicas del nexus. En la sección 1 del capítulo 5, reflexionamos de manera conjunta sobre las lecciones aprendidas de los dos primeros estudios de caso.

iii. Estudio de caso: "Don´t they understand climate science? Reflections in times of crisis in science and politics"

En este estudio caso, analizamos críticamente las reacciones en forma de narrativas polarizadas que emergen en el sitio web social IFLS ante una señal mórbida de la crisis generalizada de legitimidad de las instituciones de gobernanza: la elección de Donald Trump como presidente de Estados Unidos a finales de 2016. Dichas narrativas anuncian, a groso modo, que el "cambio climático es una cuestión de la ciencia y la ciencia trata sobre la verdad y los hechos, pero ellos no entienden la ciencia del clima".

En una primera fase analítica, conceptualizamos las principales narrativas emergentes en el sitio web IFLS a través del método de análisis cualitativo de "Grounded Theory" (Creswell, 2014), dada su idoneidad para analizar interacciones entre actores sociales en el sitio web. Este método se enmarca además dentro del enfoque de análisis situacional desarrollado por Clarke (2005), el cual hemos usado como referente teórico en el marco de trabajo de esta investigación. De hecho, Clarke (2005) señala que el enfoque de análisis situacional se ha desarrollado para enriquecer este método tradicional de "Grounded Theory". A través de este método cualitativo, codificamos un conjunto de datos que han sido seleccionados sistemáticamente en la web social IFLS (posts introducidos por los administradores de la web en forma de material audio-visual y textual, y comentarios de los participantes). Posteriormente, identificamos patrones de interacción hasta conceptualizar tres principales narrativas basadas en la ciencia del clima. En la segunda fase del análisis, rastreamos históricamente algunas de las visiones idealizadas que se promueven en estas narrativas, a la luz principalmente de creencias y características centrales del llamado modelo moderno conceptual (Funtowicz y Strand, 2007) y del modelo del déficit público, el cual reapareció a mediados de los 80 (Bauer, 2009).

En una tercera fase, analizamos críticamente la narrativa conceptualizada más predominante en la web social con el propósito de abrir un espacio de diálogo público, e identificar criterios para la gobernanza de la cuestión del cambio climático en condiciones de alta incertidumbre y complejidad (Funtowicz y Ravetz, 1993). Para ello, aplicamos dos perspectivas críticas de forma diferente. Por un lado, *revisamos* de forma didáctica la postura crítica de Irwin y Wynne (1996) sobre la visión de la ciencia y la tecnología del modelo del "déficit público" y exploramos si el diálogo público sobre la cuestión del cambio climático podría estancarse cuando interactúan: a) aquellos que promueven la narrativa criticada con asumida tendencia a proponer "soluciones tecnológicas" al problema del cambio climático, b) las voces que critican dicha narrativa tomando una postura similar a la de Irwin y Wynne (1996), y por último y no menos, c) aquellos actores referidos como "ellos" dentro de la narrativa criticada.

Por otro lado, *adoptamos* una postura crítica hacia la narrativa identificada que más predomina en la web social basándonos en el trabajo de Funtowicz y Strand (2011), para desplegar algún criterio para la gobernanza del cambio climático *en* condiciones de complejidad y alta incertidumbre. Para ello, primero analizamos cómo la misma condición de alta incertidumbre se gestiona en un discurso del gabinete político de Donald Trump sobre el cambio climático (fuera de la web social de IFLS). Esto nos ayuda a entender mejor las reacciones dentro de la web social. Posteriormente, exploramos como la condición de alta incertidumbre desarma un principio de legitimidad central del modelo moderno que se (re)invoca en la narrativa criticada. En consecuencia, desplegamos un criterio para tratar con la cuestión del cambio climático. En la sección 2 del capítulo 5, realizamos una reflexión "post hoc" sobre esta perspectiva crítica adoptada y consideramos la lección aprendida de la revisión de la postura crítica de Irwin y Wynne (1996), para responder a la segunda pregunta de investigación.

Asimismo, en la sección 3 del capítulo 5, reflexionamos sobre el conjunto de perspectivas críticas aplicadas en todos los estudios de caso y sugerimos una lección de corte transversal. En los siguientes capítulos (2, 3 y 4) se desarrollan los estudios de caso presentados en esta sección.

Chapter 2.

Case study: Which roles can innovation play in the idealised sociotechnical future announced in the EU2020 strategy?

"Innovation for smart, sustainable and inclusive growth" is the promissory sociotechnical future announced in the Europe 2020 discourse to recover from the 2007–2008 financial crisis. This chapter critically investigates a) the role of innovation in shaping this discourse in nexus governance and b) the type of policy work exercised by this discourse for the nexus and on society. For this purpose, we draw on Foucauldian discourse analyses to discuss the EU2020 discourse as a form of neoliberal political rationality aimed at relaunching the single market, expanding economic growth and (re)legitimising the European project in a crisis of legitimacy. On the one hand, innovation enables nexus concerns to be translated into a discourse of win-win solutions. On the other, innovations are actions-oriented and contribute to formulating concerns for the nexus. The discourse also upholds the conditions that do not act on inequality and threaten aspects of human well-being.

Keywords: Europe 2020 strategy; innovation; Foucault; nexus; human condition

1. Introduction: context and purpose

While contemporary history is notoriously difficult to write, our qualified guess at the beginning of the 21st century is that future historians may come to identify the belief in innovation as a key feature in promissory political discourse of parts of the 20th and 21st centuries. This chapter zooms into one instance of such political discourse, the Europe 2020 Strategy (European Commission, 2010a) of the European Union (EU) and critically analyses it in order to better understand how such discourse is shaped via innovation in nexus governance, and what kind of policy work this discourse exercises in terms of issues of sustainability, aspects of human well-being and social justice. In order to do so, we draw upon the tradition of discourse analysis originating from Michel Foucault (Foucault, 2008), several interpreters of his work (Ahlqvist, 2015; Barry, 1993; Lemke, 2001, 2002; Read, 2009) and intellectual resources from the heterodox history of economics (Reinert, 2007, 2016), post-normal science (Benessia and Funtowicz, 2015, 2016) and critical studies of innovation (Godin, 2006b, 2014a, 2014b)

Specifically, the Europe 2020 Strategy was adopted in June 2010 in the form of a communication (European Commission, 2010a; European Council, 2010). Although this type of summary from the dialogues within EU institutions may not appear significant, it is particularly important. This communication outlines how the European Commission envisions the EU response and recovery from the financial crisis of 2007–2008 via innovation for "smart, sustainable and inclusive growth". In this chapter, we will try to argue how and why this idealised sociotechnical future based on innovation could appear to be *rational* and promising from *within* certain institutions, while less convincing to the rest of society.

However, the issue at stake goes beyond contrasting perceptions. Indeed, the strategy is articulated through several headline targets to be tailored by the EU members and, by its own assessment, the Commission concludes that the indicators of poverty and social exclusion are not within close reach of their Europe 2020 national targets (European Commission, 2014c, 2014a). Similarly, in the long-term assessment, the Commission points out that there is no significant improvement in these issues and that the economic recovery from recent years has not benefited all citizens to the same extent, which is mainly attributed to the divergent impact of the financial crisis of 2007–2008 across Europe (European Commission, 2019a). The lack of early success in these issues has been discussed by several scholars. Daly (2012) claims that the EU2020 presents a lack of internal coherence since it is grounded in social investment and ideas of liberalism, not strongly oriented to tackling poverty and social exclusion. Along similar lines, Cantillon (2011) and Marques et al. (2015) emphasise a shift from old redistributive politics in the Lisbon Strategy to an EU2020 agenda more based on social investment. Arriazu and Solari (2015) argue that the underlying neoliberal ideology in the austerity politics applied during the economic crisis increased inequality and since these neoliberal values are present in the EU2020 strategy, this problem could increase. In a similar direction, Barbier (2012) argues that there has been a marginalisation of social policy against macroeconomic and financial concerns, which could partly be explained by actors in leadership positions promoting their own agendas.

We do not disagree with any of the above-mentioned criticisms. We will try to argue, however, that the problems run deeper, beyond conflicts of interests, internal inconsistencies or an underlying neoliberal ideology. Rather, they are connected to the very understanding of a) what innovation can provide and which (actual) roles it can play in governing the nexus and shaping the idealised EU2020 discourse and b) what kind of practices and policy work this discourse exercises *for* the nexus, certain human aspects of well-being and equality. In order to develop our argument, we refer to Foucault's (2008) work on discursive formation. Foucault (2008) analyses liberalism from the mid-18th century and then neoliberalism after World War II (WWII), more specifically contemporary German liberalism, not as an ideology or an economic theory (Cotoi, 2011), but as a form of political rationality characterised by the articulation of a particular type of economic thought and set of governmental practices and rules aimed at creating a competitive market economy. In this way, we will critically analyse the EU2020 discourse as a form of political rationality, inspired by that of German-post-war liberalism and aimed at relaunching the European single market in a situation of crisis of legitimacy of the European project (Kovacic et al., 2019).

The chapter is structured as follows. First, we introduce Foucault's theoretical framework in discursive formation and why and how it is used, to develop our argument. In the following section, we unpack the promissory EU2020 discourse about innovation-based "smart, sustainable and inclusive" growth, with special focus on the idealised role of innovation in it. Next, we discuss this idealised discourse by drawing on the theoretical lens provided. On the one hand, we shall investigate how the discourse is shaped via innovation in the nexus governance and what type of policy work is exercised (and how) by this discourse *for* the nexus. And on the other, we shall investigate how innovation-based discourse exercises specific domains of intervention in society and what kind in terms of human aspects of well-being and equality. In the last section, we will provide some concluding remarks.

2. Theoretical and methodological framework

The EU2020 Communication announces an idealised sociotechnical future via innovation that is articulated through several flagship initiatives and headline targets. We aim to go beyond the face-value role of innovation of bringing about the idealised and hopeful future that the Communication announces and provide a better understanding of the (actual) roles that innovation can play in nexus governance and in shaping the EU2020 discourse, and what kind of practices this discourse exercise for the nexus and on society. To this end, we draw on the Foucauldian perspective in discursive formation (Foucault, 2008), the purpose of which is to understand epistemological ruptures, that is, how discourses and practices go out of and come into existence (Faubion, 2000) (Gale, 2001).

Particularly, Foucault (2008) tries to study how specific contemporary issues such as population health or birth rate have been posed within a political rationality which has been deeply intertwined with the question of liberalism since the end of the 18th century. More specifically, Foucault (2008) analyses liberalism from the mid-18th century to the then contemporary German liberalism (ordoliberalism) after WWII as the articulation of a particular type of economic thought and set of governmental practices and rules to "create a competitive market economy". In this way, we will assess the EU2020 discourse as a form of political rationality (inspired by ordoliberalism) with a view to "further developing a single market". Next, we will first briefly introduce what this political rationality means by looking at its historical evolution from the mid-18th century to the post-WWII period (subsection 2.1). Then, we shall explain why and how this political rationality is specifically used to develop our argument (subsection 2.2)

2.1 From the naturalness of the market to the competitive market economy after WWII

While always difficult, Foucauldian analyses perform certain epistemological distance over historical time. When introducing his analysis on the historical evolution of the so-called "liberal art of the government" below, we have established this distance from our own positioning outside classic economic schools and closer to heterodox traditions in economic history and development economics (Chang, 2004; Orduna, 2000; Reinert, 2007, 2016).

Within the "liberal art of the government" from the mid-18th century, political economy plays a key role, in which the classical works of the physiocrats and of Adam Smith stand out (Gudmand and Lopdrup, 2009). Smith, for example, aspires to a space of moral individuals in an ideal market of freedom and commonwealth through the development of the manufacturing trade taking place in England and Scotland in the 18th century (Casassas, 2013; Aguilera, 2013). Both for Smith and the physiocrats, the freedom of the market is a necessary condition for the so-called *natural* price to be formed and for the *natural* game of competition to lead to mutual enrichment. This *naturalness* of the market is a feature embedded in the literature by that time such that the market appears as something that obeys to spontaneous and intrinsic mechanisms "out there" (Gudmand and Lopdrup, 2009). According to Foucault (2008), this type of thought introduces a) a "selflimitation" in the sense that governmental practice has to respect that nature of the market and b) a "regimen of truth" in the sense of the appearance of "new economic experts whose task is to tell the government what in truth the natural mechanisms are of what it is manipulating" (Foucault, 2008: 17). Furthermore, these ideas that the naturalness of the market reveals something like "truth", form an "apparatus" of knowledge-power that justifies the belief that governmental practice can be verified and falsified in terms of what it does, the measures it takes and the rules it imposes. At a subtler level, this type of thought and set of practices is successfully extended in human conduct through state administration.

According to Foucault (2008), political economy is also articulated with the objectives of the state's enrichment through unlimited goals in the form of imperialism and the idea of free competition between states. In this sense, the classical work about free trade by David Ricardo to expand British manufacture by the mid-19th century can be an illustrative example. Ricardo imagines a situation with two countries, takes their current levels of technological development for granted and formulates that both countries would benefit from "free trade" if they specialised in the production of goods whose relative costs are lower (Orduna, 2000). This theory enables the British state to specialise in manufactured products since it has "better conditions", while the colonies should specialise in unmanufactured products (Reinert, 2007). However, these "better conditions" are paradoxically gained through intervention policies which promote domestic manufacture such as the Tudor Dynasty Policy from 1485 to 1603 or the so-called Plan of the English Commerce (Chang, 2004). Overall, this strategy was later imitated by many European countries to develop their economies (Reinert et al., 2016). In their quest to become rich and establish the order of commercial freedom claimed by the classic economists, European countries first create favourable conditions and promote its manufacture through specific intervention policies. Then, they apply "free trade" discourses to further develop their economies but suppress a similar development in the colonies, as well as neighbouring countries (Orduna, 2000), by adopting the practice that has been called the "impoverishment of the neighbour" (see, for example, the case of Portugal in Robinson 1979). In other words, the rich become richer, and the poor become poorer. Colonialism was morally legitimated in the 19th century by applying these "free market" policies (Reinert, 2007).

Overall, there is a core paradox involved within this "liberal art" from the mid-18th century: a formidable body of legislation and governmental interventions is actually necessary to produce and organise an order of "natural commercial freedom", which in turn is needed to govern (Foucault, 2008:64). Consequently, this type of thought about the naturalness of the market and paradoxical set of practices facilitate the insertion into discourse of something that does not exist, namely the fictional situation of the "free market". Moreover, all this governmental intervention brought the crisis of this "apparatus" which manifests itself in a number of theoretical (re)configurations undertaken by the so-called ordoliberals[7] to (re)establish the political economic order in the context of the German policy after WWII (Gudmand and Lopdrup, 2009).

Specifically, the ordoliberals analyse the experience of the emergence of Nazism as an unlimited growth of power and increasing governmental intervention by the state, allowing them to accelerate the resolution of an ongoing problem since the 1920s: how a free-market economy can serve to legitimate and found a state which could be trusted by everyone (Lemke, 2001). To resolve this problem, the ordoliberals first reversed the relationship defined by 18th-century liberalism arguing that it is naive to believe that a market of exchange and competition exists as a sort of given spontaneous nature which the state must respect and allow to be free. Instead, *competition* is placed at the centre of the economic analysis and defined as a(n) (artificial) structure with formal properties that ensure economic regulation through the price mechanism (Read, 2009) (Cotoi, 2011). Then, the problem was to develop the concrete space in which the (artificial) formal mechanisms of the market could appear, function and produce their positive effects. In other words, ordoliberalism does not aim to intervene in market mechanisms but in market *conditions*, that is, the so-called institutional framework (Foucault, 2008). To paraphrase Foucault (2008): one must govern for the market rather than because of the nature of the market. In this direction, Lemke (2002) pinpoints how the neoliberal political rationality is based on a discursive field that exercises power by functioning as a "politics of truth", that is, while different concepts and notions are invented and explicitly suggested as already existing (as "truth"), such notions deploy new domains of

[7] The term "ordo" comes from a series entitled "The Ordo Manifesto of 1936" directed by the German economists Walter Eucken, Franz Böm and H. Grossmann-Doerth. Later, "ordo" became the title of the academic journal founded in 1948 by Eucken, who also formed the Freiburg School. Ordoliberal ideas are promoted by Müller-Armack, Friedrich von Hayek and Ludwig Erhard, among others (Foucault, 2008). Economists from the Anglo-American and Austrian Neoclassic School also engage with the so-called "renovation of classical liberalism" but in different ways from the ordoliberals (Puello-Socarrás, 2007).

extensive regulation and intervention. In Lemke's words, this political rationality construes neoliberalism "as a political project that endeavours to create a social reality that it suggests already exists" (Lemke, 2001:203)

2.2 The European project and the creation of a common market

According to Foucault (2008), this type of (ordoliberal) rationality appears embedded in foundational discourses of the European project such as the Treaties of Rome in 1957, especially the treaty that establishes the European Economic Community (EEC). This EEC Treaty, actually entitled the Treaty on the Functioning of the European Union, was originally succinctly aimed at the "creation of a common market" based on the free movement of goods, people, services and capital (European Union, 2017). Specifically:

> The aim of the EEC (European Economic Community) and the common market was to 1) **transform the conditions** of trade and production on the territory of its 6 members (Belgium, Germany, France, Italy, Luxembourg and the Netherlands) and 2) serve as a step towards the closer political unification of Europe (European Union, 2017) [8]

Similarly, ordoliberal ideas are embedded in the goal of developing a Common Agricultural Market, an issue included in the EEC Treaty. In Foucault's words: "What must be done if we want European agriculture to function within a competitive market economy? (Foucault, 2008:141). According to ordoliberal thought, we should act on condition*s* such as the size of the agricultural population, techniques and technologies, training, the legal system, government incentives (e.g., subsidies), the availability of land or even the climate, for agriculture to be able to function within a competitive market.

Several scholars have critically analysed European discourses from this Foucauldian perspective (Ahlqvist, 2015) (Shore, 2009) (Barry and Walters, 2003) (Barry, 1993). Barry (1993), for instance, examines how the idea of harmonisation became a central technical means by the 1980s to facilitate the free mobility of goods, persons, services and capital across the European space, under the goal of establishing a "single market" and a "market integration". From this perspective, subsequent efforts toward a higher degree of "market integration" can be observed with the consolidation of the Maastricht Treaty in 1992 (European Union, 1992) (formally known as the Treaty on European Union), and the creation of an Economic and Monetary Union since the 1990s (European Central Bank, 2021). However, the European single market, backed by a common

[8] The bold is mine to highlight a certain resemblance to ordoliberal ideas.

currency by the 1990s, is relatively recent when compared with the large home markets of China, the US or Japan.

In this chapter, we critically discuss a key contemporary discourse, namely the innovation-based EU2020 discourse, as a type of neoliberal political rationality whose aim was to "relaunch the single market" (European Commission, 2010a: 20) within the making of the European project. Specifically, the EU2020 strategy announces that the single market has shown signs of "integration fatigue and disenchantment" (European Commission, 2010a: 20) and should be re-launched to deliver "smart, sustainable and inclusive" growth and job creation through several political initiatives that include dealing with fragmentation and diverging rules deriving from 27 different legal systems.

In this way, we will discuss the EU2020 discourse as a type of neoliberal political rationality aimed at reinstating further integration of the single market in a situation of crisis of legitimacy of the European project (Kovacic et al., 2019). Specifically, the analysis is structured in two parts. In the first, we will critically investigate how the EU2020 discourse is created and shaped by looking at the role that innovation can play *in* the governance of nexus tradeoffs, and what kind of policy work this discourse exercises *for* the nexus and sustainability (and how). To undertake this analytical part, we have applied a certain analytical distance between innovation, the nexus and the political discourse, understanding their increasing interactions as part of a political project in the making. Regarding innovation, we sympathise with the concept of "sociotechnical imaginary" provided by Jasanoff and Kim (2009), whereby innovations are understood as hypothetical projections and imaginaries towards the future linking science, technology and society altogether and projected collectively by certain communities and actors who share the articulation of problems. Regarding the nexus, by 2010 this word itself was not yet very popular on the European political stage (its popularity emerged gradually with the Bonn 2011 Conference, Hoff, 2011). However, nexus concerns such as "pressure on the environment posed by expansion of population growth", climate change, scarcity of natural resources or fossil dependence are acknowledged within the EU2020 discourse (European Commission, 2010a). In addition, in this first analytical part we have placed a certain epistemological distance over historical time from our position outside of ordoliberal thought and closer to scholars mainly from post-normal science and critical studies of innovation (e.g., Godin, 2006b, 2014a, 2014b; Benessia and Funtowicz, 2015, 2016).

On the other hand, in the second part of our analysis, we will examine how the idealised EU2020 discourse exercises specific domains of intervention in society and what kind, in terms of aspects of human well-being and equality. To shed some light on this question, we will examine in more detail the specificities of the so-called "social policy" within the ordoliberal political rationality and compare it with the specific type of social policy work (and practice) that is exercised through the discourse on "inclusive growth".

In the following section we first provide an overview of the EU2020 discourse with special focus on how innovation is ideally portrayed for "smart, sustainable and inclusive" growth.

3. The promissory discourse embedded in the Europe 2020 Communication

The Europe 2020 Communication announces an idealised sociotechnical future via innovation for "smart, sustainable and inclusive growth" (European Commission, 2010a). The adjective "smart" is used in several ways in EU discourse and is often defined in terms of ideals of efficient management (see, for example, smart grids in the European Commission, 2006). The emblem of **"smart growth",** however, refers to the ambition of developing an economy based on knowledge and innovation, where innovation is associated with technical progress and placed at the core of the expansion of economic growth. Under this emblem and specifically through its flagship initiative called Innovation Union, the Europe 2020 Communication prescribes that "every link should be strengthened in the innovation chain, from 'blue sky' research to commercialisation" (European Commission, 2010a: 12). The "innovation chain" may echo the so-called "linear model of innovation", which is a central element in the discourses of innovation throughout the post-WWII period in Europe and North America (Strand et al., 2016). This linear model imagines that science and technology contribute to the economy through the following sequential and unidirectional steps: curiosity-driven, basic research will provide discoveries which are then taken up by applied research that will transform them into inventions. These inventions will be developed into marketable products and services by technology developments, which will then be placed under production and released onto the market. Accordingly, higher investments in basic research will give rise to economic growth. This model, however, appears more clearly in the preceding Lisbon strategy, which set up target levels of Research and Development (R&D) spending that all member states should reach (Laurent, 2016). Low levels of investment in R&D are indeed mentioned in Europe 2020 (European Commission, 2010a: 7), but innovation is portrayed via a set of more complex interactions between basic and applied research, industrial and technological development, universities, R&D, business enterprises and commercial use. To summarise, the imaginary of smart growth implicitly assumes the central role of technoscience in the creation of innovation, economic growth and jobs, although the words "science" or "technoscience" do not appear explicitly in the Europe 2020 Communication. Indeed, it is the prospects of sophisticated technology that are typically invoked in this type of discourse when the words "blue sky" and "smart" are used.

Along these lines, investment in R&D is targeted toward certain domains of research considered as "societal challenges" (European Commission, 2014b), and techno-scientific innovation is assumed to "solve" these challenges such as climate change, energy and resource efficiency, health, demographic change or food security, to mention a few of them. Fast and accelerated technological change is presented as the main answer to all of these challenges (European Commission, 2010a:12), and political action should be tailored accordingly to facilitate the acceleration.

At the same time, the Europe 2020 Communication envisions that smart growth will be **sustainable**. Contrary to academic and political debates since the early 1970s on the difficulties of reconciling growth with sustainability (Ekins, 1993; Gómez and Naredo, 2015), the communication does not anticipate any such tension. Instead, it promotes innovation for "sustainable growth". Specifically, this discourse announces the following hopeful visions: a) decoupling growth from fossil dependence and the inefficient use of raw materials with more technological development by searching and harvesting other energy sources, b) reducing greenhouse gas emissions with new and more efficient technologies, including electric and hybrid cars in the transport sector and c) decoupling growth from the scarcity of natural resources with technological implementation by improving efficiency and ultimately substituting them with more optimised technological artefacts (for example, synthetic biology. See Benessia and Funtowicz, 2015, for a critical analysis). Within this discourse, an implicit element is that technological inventions can be brought into commercial use in the form of new and more efficient products and services, which would stabilise the demand for energy to be consumed and keep growth on track (Benessia and Funtowicz, 2016).

Within this logic, the challenge of decoupling growth from resource scarcity and environmental pressures is also seen as an opportunity for new businesses to grow via techno-scientific innovations. Specifically, European innovation is both pulled and pushed towards what is identified as its advantage: green technologies. However, since this leadership is perceived as being challenged by other competitors, such as China and North America, an accelerated development of new green technologies will increase the competitive position in the global market (European Commission, 2010a: 14). Indeed, the postulate of increased global competition is a key element in the entire underlying discourse of why innovation is needed for employment and growth. In this sense, the prosperity and the economic growth of a geopolitical region (as in the case of the EU) depends, metaphorically, on how fast it runs in the race against its competitors and how well it competes in the global market. This metaphoric view of a competition race is perceived as a competition in the speed of technological change, which is then operationalised as metrics on the frequency of high-growth, knowledge-intensive enterprises, technological readiness and technology transfer. For example, the emergence of China and India as intensive investors in research and technology is seen as a threat of being left behind in the competition race. If they invest heavily in research and technology, Europe should do the same to remain competitive.

At the same time, smart and sustainable growth is expected to create more jobs, improve social and territorial cohesion under the emblem of **"inclusive growth"**, so that everybody can benefit from growth. The ambition of inclusive growth is articulated through two main interlinked flagship initiatives: "An agenda for new skills and jobs" and the "European platform against poverty". The former promotes labour mobility and aims to "modernise labour markets" (European Commission, 2010a: 6), that is, provide parts of the workforce with new skills to improve their productivity and adaptability to the innovation economy. Specifically, the so-called "labour market's demand for high skills" is foreseen to increase considerably by 2020, where more education, training and lifelong learning principles are key in the acquisition of these new skills, targeting specifically, but not exclusively, women, older workers and migrants. Similarly, the aim of the second flagship initiative is that people experiencing poverty and social exclusion 1) should live in dignity by ensuring better access to health care and adequate income support through social protection and pensions systems and 2) should "take an active part in society" (sic!) (European Commission, 2010a:19) through "social innovation" that encompasses education, training and employment opportunities.

Overall, a key instrument such as the "single market" should be "stronger, deeper and extended" (European Commission, 2010a: 20) to deliver the goals of smart, sustainable and inclusive growth. Furthermore, the communication justifies these goals by referring to European values as strengths that will contribute to the realisation of these same these goals. Among these values, we may mention strong democratic institutions, cultural diversity, the consideration for economic, social and territorial cohesion and solidarity, respect for gender equality and the determination to act collectively "as a Union" (European Commission, 2010a: 9).

4. The EU2020 discourse in the making of the European project

In the previous section, we provided an overview of the content and justifications of the Europe 2020 discourse in terms of its own internal logic. In the first part of this section, we investigate how this discourse is shaped via innovation in nexus governance and what kind of policy work exercises for nexus governance. In the second part, we investigate how the discourse exercises specific domains of intervention on society and what kind in terms of aspects of human well-being and equality.

4.1 The role of innovation in (and for) nexus governance

The term itself, *innovation,* has changed meaning several times in history, from being seen as predominantly negative (as heresy or a shallow representation of something old as something apparently new) to predominantly positive (Godin, 2014b). This shift took place within a broader cultural shift in Western civilisations in the 19th and 20th centuries towards embracing newness and novelty as something desirable and good in and of itself and under the influential idea of progress and utility (Godin, 2014a). Gradually, in the late 19th and early 20th centuries, innovation became synonymous with invention, above all invention created or inspired by science and engineering. Godin (2006b) explains how different scientific communities (academic and industrial researchers as well as economists and statisticians) contribute in the early and mid-20th century to developing the beliefs that became known as the linear model of innovation. Within innovation studies as well as science and technology studies, the linear model has been refuted by countless empirical studies. Yet it persists in written or oral policy discourse. For instance, Camagni and Capelo (2013) try to fit territorial and regional specificities of many EU countries into the linear model to better channel funds to those countries or regions that have more similar features in some of the phases. In the EU2020 discourse, innovation is portrayed via a more complex set of connections between basic and applied research, technological development, industries, universities, business enterprises and economic growth. Therefore, practically any contemporary discourse on innovation-for-smart growth is associated with the hope invested in technoscience as the main engine of economic growth and is envisioned either via this linear model or by a more complex set of connections. Accordingly, we should ask what innovation can provide that renders these discourses so persistent. The first and obvious answer is that innovation provides a justification for funding (and appreciation) of basic research because it claims that basic research is the main source from which inventions emerge.

At the same time, innovation is envisioned as the driver that will "decouple economic growth from fossil dependence and the scarcity of natural resources and reduce CO_2 emissions" under the emblem of sustainable growth. This emblem has been further developed in political initiatives that postulate "Innovating for Sustainable Growth: A Bioeconomy for Europe" (European Commission, 2012). Such discourses are not original within European policies and they echo the discourses of the Organization for Economic Co-operation and Development (OECD, 2005) and the US Energy Policy Act of 2005 (Cooper, 2007). Specifically, the latter discourse can be traced back to the US political reaction to the so-called oil crisis of the early 1970s (Cooper, 2007). After WWII, US planners worked to engineer a political and economic order to convert Europe's energy system into one mainly based on the oil-dollar by articulating oil flows with financial flows from debt. However, the oil crisis, arguably related to higher costs on access and extraction of crude oil (Mitchell, 2009), rendered this oil-dollar articulation less capitalisable, and created a political arena for the emergence of a discourse on sustainable growth and bioeconomy via the scientific and industrial development of biotechnology. Regarding the EU2020 discourse, we should accordingly ask what innovation can provide that renders this discourse so promising. In what follows, we shall argue that innovation can play a specific role in shaping the EU2020 discourse through its intersections with the nexus tradeoffs.

The EU2020 discourse warns about fossil fuel dependence and climate change deriving from economic growth, as well as the pressure on the environment that will be posed by the expansion of the world population (European Commission, 2010a:6). In addition, the discourse implicitly admits that we cannot keep growing under the problems associated with pollution and the pressure of scarce natural resources on a finite earth. Therefore, the way out of these predicaments comes from techno-scientific innovation (Benessia and Funtowicz, 2015). Speaking of tensions between economic activities and the environment, and of limits of economic growth imposed by a finite earth, is a way of speaking about nexus concerns (Rommetveit et al., 2013), even though the word nexus does not appear explicitly in the EU2020 discourse. Indeed, it is interesting to note that food security is one of the societal challenges of the Europe 2020 Strategy (European Commission, 2014b), and this concept is echoed in the so-called "water, energy and food security nexus" (Cairns and Krzywoszynska, 2016).

More specifically, innovation appears as a central means to overcome those tensions (nexus tradeoffs) by seeking other energy sources (e.g., biofuels derived from biomass, European Commission, 2012), reducing CO_2 emissions via new and more efficient technologies (e.g., electrical cars) and even substituting natural resources with more optimised technologies (e.g., through synthetic biology). Simultaneously, and following the theoretical lens introduced in section 2, innovations are seen as marketable products and services within a neoliberal political rationality with a view to relaunching the single market and expanding economic growth. This way, at the level of policy discourse, innovation appears primarily as a legitimate central technical means that reconciles the goal of economic growth (and market-making) with environmental problems. For instance, in the biofuels' case, these innovations are envisioned as relieving the concern on fossil dependence (e.g., as "bio, green or renewable") and also as fuels for keeping economic activities on track. Electrical cars are another case in point: they are envisioned as reducing greenhouse gas emissions and thus as "eco-friendly or clean" (if electricity is produced from renewable energy sources), but also as marketable "cars".

In this direction, several scholars have argued that contemporary discourses on "sustainable growth" or the "green economy" transform the language of a discussion of "tradeoffs" and "limits" into a discourse of opportunities and win-win solutions through technological solutions, "silver bullets" and managerial environmental approaches (Cairns and Krzywoszynska, 2016; Leese and Meisch, 2015; Voelker et al., 2019). The silver bullets or technical fix for nexus tradeoffs and sustainability issues have also been associated with certain imaginaries evoked by technoscience (Benessia and Funtowicz, 2015). Specifically, Benessia and Funtowicz (2015) critically analyse the EU2020

Communication and argue that sustainability is framed by evoking an imaginary of control together with that of power, wonder and urgency. Such imaginaries can be traced back to the early modern period in European history, namely, with the appearance of the modern state and, above all, to Francis Bacon (Rommetveit et al., 2013). Bacon imagined a utopia in which Man masters Nature by means of the new scientific method. Once, – to paraphrase Bacon – "we" scientifically know the causal relations in nature of whatever is desirable, the effects can be produced. In the same way, "we" may actively avoid natural disasters and other threats by removing their causes. This imaginary in its original form was tremendously optimistic. Causal relations were imagined as simple, monocausal and unidirectional, whereas collaterals or unforeseen and undesired effects were not imagined. Bacon never problematised the "we"–there was already a collective subject in place that agreed on what was beneficial or harmful. Indeed, he spoke optimistically of new weapons to defeat the enemy, without discussing the possibility that the enemy might also acquire the new sciences (Rommetveit et al., 2013). What emerged from this early modern imaginary of power and control was the belief that any science-induced change through technology would inevitably have desirable consequences.

The technical fix has also been the subject of critical analysis in science and technology studies and the history and philosophy of technology which have pointed out its failures and disappointments (see, for example, Maclaine Pont et al., 2016). However, the point goes beyond contrasting perceptions or repeatedly showing the failures that a technological innovation might pose through its implementation (e.g., its lack of guaranteed delivery of sustainable development). Indeed, the actual success of a (techno-scientific) innovation in terms of its implementation and effects in the material world is not necessarily important or even relevant. Rather, innovation "solves" a problem in the sense that it brought about a policy solution (as a primary idea or imaginary) that promises two wins *in* the governance of nexus concerns, and this idea embodies two values that are usually in conflict or contradiction. In other words, the actual role of innovation is that it solves value problems within a certain community of experts and policy makers (such as "What to do?" and "What to aim for?") and allows them to move forward with a political decision.

At the same time, innovation-based policy might work as a "politics of truth" and might actually be implemented in the material world through the deployment of domains of extensive intervention (Lemke, 2002). In this sense, innovations are actions-oriented and such intervention may implicitly prioritise and promote some policy targets over others by making them viable or by, unintentionally, causing new problems or aggravating existing ones in other parts of the nexus. For instance, while projections of innovations such as biofuels (European Commission, 2012) are inserted in the discourse as win-win solutions (for the economy and the environment) and discursively suggested as truth, innovation imaginaries exercise new domains of regulation and practices (e.g., changes in legislation, mobilisation of different actors, setting targets at European or national level, etc.) to tailor and support that hypothetical projection. And if these technical solutions were implemented on a large scale, energy policy targets would be prioritised over agricultural policy targets or biodiversity. Those solutions are *fuel* solutions that respond primarily to energy security concerns to keep economic growth on track (Kovacic, et al., 2020).

To recapitulate, innovation enables (nexus) concerns and tradeoffs to be translated into a discourse of win-win solutions by announcing a reconciliation between environmental problems with the goal of economic growth (and market-making). Such discourse, by functioning as a politics of truth, exercises a policy work to tailor and facilitate that fictional projection of social-technical order toward the future, to the extent that this policy work might be seen as simply giving a helping hand to technological processes that must and should take place anyway. At the same time, *if* innovations were actually implemented on a large scale, they would involve implicit priorities *for* the biophysical nexus because they are actions-oriented and they might create unexpected new tradeoffs, aggravate existing problems in other parts of the nexus and ultimately cause unsustainable patterns. However, *within* the discourse of innovation, it would be difficult if not impossible to explicitly advocate the undesired effects of innovations. Rather, it is claimed that innovation will deliver sustainable growth. Precisely, because the actual role of innovation is to "solve" a value problem in the sense that it brings about an imaginary that promises two wins *in* the governance of the nexus, and the imaginary is introduced in the political discourse without too much attention being paid to the difficult tradeoffs posed by its large-scale implementation (e.g., the materials extraction phase to produce electrical cars or the aggravation of biodiversity in the case of biofuels).

4.2 The ambition of innovation-based inclusive growth

In the EU2020 discourse, innovation-based smart and sustainable growth is anticipated to be socially inclusive, that is, everyone can benefit from growth. Drawing on the theoretical lens provided in section 2, we ask what kind of social intervention is exercised by this idealised discourse that aims to relaunch a competitive single market based on (techno-scientific) innovation. For this purpose, we will revisit two specificities of the so-called social policy that should be in line with a competitive market within an ordoliberal political rationality, and we will compare them with two respective flagship initiatives that articulate that ambition of inclusive growth: "European platform against poverty" and "An agenda for new skills and jobs".

After WWII, the ordoliberal thought, in its particular historical context, reversed the naive idea defined by 18th-century liberalism about the belief of a market of competition and trade that involved a type of spontaneous nature which should be left free. Instead, competition was placed at the centre of economic analysis and was defined by a structure with formal properties that assured economic regulation through the price mechanism. According to this thought, a concrete space in which those market competition mechanisms could appear and produce positive effects should be developed (Cotoi, 2011). Particularly, this thought was especially peculiar in defining the so-called social policy that should be in line with such a competitive market (Gudmand and Lopdrup, 2009). The price mechanism is obtained through a game of differentiations and only produces its regulatory effects if fluctuations are left to work and compete through differences. Consequently, a social policy in line with this mechanism could not have full equality as its objective since it would be considered anti-economic. On the contrary, it must let inequality function (Foucault, 2008: 143). Within this thought, the economic game was to be reorganised through rules in the form of laws. An unconditional rule of the free market welfare state is that no partner in the game can lose everything and be unable to continue playing. Thus, if there is a need, some kind of social protection can be provided, but it will have to be at the lowest level lest it disrupt the economic game. In this way, this social policy will never act directly on the causes of poverty and the destructive effects of the market on society. It means that there will be a kind of "liminal population which, for an economy that has abandoned the objective of full employment, will be a constant reserve of manpower which can be drawn on, if need be, but which can also be returned to its assisted status if necessary" (Foucault, 2008: 207).

This social adjustment resembles one of the flagship initiatives that articulate the ambition of inclusive growth: "European platform against poverty". This flagship initiative promises to lift "over 20 million people out of poverty" (European Commission, 2010a:11) through key instruments: ensuring adequate income support and taking "an active part in society" through so-called "social innovation" (European Commission, 2010a: 19). Specifically, ordoliberal ideas resemble this discourse in the following sense. First, the social intervention exercised within the ordoliberal political rationality is exemplified by this so-called social innovation, which is to be developed by a previous "social experimentation" (European Commission, 2010b: 14), that is, by designing and undertaking small scale projects to scientifically test and assess social policies before they are scaled up. This social innovation is closely related to education and training, and through this, labour participation will increase and structural unemployment (which is also known as the natural rate of unemployment, OECD 2001) will be reduced (European Commission, 2010a: 18). This way, the most vulnerable will "take an active part in society "(European Commission, 2010a:19) in the innovation-based market economy. Second, if necessary, they (the most vulnerable) could also return to assisted status, assured by certain social protection (adequate income support). In line with ordoliberal thought, such social protection should be at the lowest level in order to not disrupt competition in the market: this social policy does not and cannot act, therefore, on the causes of poverty. Indeed, the word "inclusive" does not imply the same conditions for all and that everyone will actually benefit equally from an innovation-based market economy. The importance of this point is seen even more clearly if we compare our contemporary time to that of the early 17th century, when innovation meant something closer to heresy (Godin, 2014b). Regardless of living in a culture that generally embraces what is new, an innovation-based market economy also creates destructive effects on society. Within the official political discourse of the EU, it would be difficult if not impossible to explicitly champion the deliberate creation of destructive effects. On the contrary, it is universally claimed within the institutions of the EU that innovation should benefit everyone.

In what follows, we shall highlight another specificity of a social policy within an ordoliberal rationality that can be traced back to mid-18th-century liberalism, and we shall compare it with the flagship initiative: "An agenda for new skills and jobs". The so-called "well-functioning competitive market" of mid-18th-century liberalism was originally built under a peculiar premise in modern societies. In one way or another, time became commoditised for both the employer and the employee through the so-called "well-functioning market" (Strand, 2013). For the employer, production costs must be kept down, so workers' time became a direct cost to be optimised (by getting more output from the same passage of time at the same cost, or by getting the same output from less work time). Furthermore, since production could be optimised by making labour more intensive, hurried and harder, it would often be a *matter of suffering* for the employee, which could be compensated with payment. On top of this strange market, technological development could make production more efficient and sometimes also reduce the hardships for the employee at the workplace. Paradoxically, new technology could also automatise jobs and contribute to unemployment in the name of efficiency. Foucault scholars have argued that in contemporary neoliberalism a subtle type of mentality is required in the competitive market which is actualised in habits and perceptions (Read, 2009:34). According to Foucault (2008), within an ordoliberal, political rationality, society was to be permeated and organised by a subtler form of competitive enterprise, which extends into the individual's relationships with private property, insurance, retirement, and even his or her time at work, with the family and so forth. For instance, these subtle forms might be found in feelings of guilt such as that of spending time that could have been used in productive work or that one might have been more efficient at work (which would simply mean that the employer became more competitive, that is, a larger profit would be gained if employees worked harder for the same payment; consequently, employees would bring suffering upon themselves) (Strand, 2013). We may contrast this relation with the passage of time at work with the particular requirements introduced by the "agenda for new skills and jobs", namely, the very goal of "modernis[ing] labour markets" in the Europe 2020 discourse. Citizens are supposed to be willing to enter the innovation-based competitive market by acquiring new skills to improve productivity and adaptability to the innovation-based competitive market economy. Particularly, it is expected that there will be an increase in jobs that will not demand "low or basic skills" (European Commission, 2010a: 18). It is difficult to see what this could mean other than increasing demands of work efficiency and a more subtle type of competitive mindset with the resulting strains on the workforce, now predominantly on mental and psychosomatic health rather than the "old" physical risks (Strand, 2013). Under these requirements, one wonders why an unemployed citizen with low skills should embrace an innovation-based competitive market.

Indeed, from the analysis above it is not surprising why neither flagship initiatives succeeded in their implementation (European Commission, 2014a). Rather, one could expect that remedial actions based on innovation for growth to recover from the financial crisis of 2007–2008 would aggravate social problems.

5. Concluding remarks

In this chapter, we have discussed the role that innovation can play in shaping the idealised EU2020 discourse and (re)legitimising the European project in a situation of crisis of legitimacy exacerbated by the financial crisis of 2007–2008, and what kind of policy work this discourse exercises for the nexus and on society.

On the one hand, in nexus governance, innovations enable nexus tradeoffs to be translated into a discourse of win-win solutions (for the environment and for the economy). Specifically, they are introduced in the political discourse as (sociotechnical) imaginaries and such discourse exercises power by being discursively suggested as truth. At the same time, innovations are actions-oriented, posed within a neoliberal rationality aimed at further developing the single market via marketable products and services and expanding economic growth. And *if* they were implemented, they would implicitly involve biophysical priorities for the nexus by supporting some policy targets over others. In this way, they might create unexpected new nexus tradeoffs, aggravate other parts of the nexus or, ultimately, threaten the sustainability of socio-ecological systems. On the other hand, the idealised EU2020 discourse exercises a specific type of social policy work that involves at least two dimensions: a) social innovation for the most vulnerable to take part in the innovation-based market economy, combined with social protection in the event that the most vulnerable remain unemployed and b) a type of competitive mindset required of citizens to be able to work in the competitive market economy. This type of social policy work upholds the very conditions that do not act on the inequality created by the innovation market economy and might threaten the human condition in its many complex aspects of well-being.

Overall, the continued persistence of this type of articulation of discourse and practice within certain official institutions may uphold the very conditions that also create a democratic deficit, which we believe manifested itself in the 2010s. In this sense, it is not surprising that the EU2020 discourse is less convincing to the rest of society as witnessed by the outcome of the Brexit referendum in 2016 and political anti-establishment movements across Europe (Callinicos, 2017; Pirro and Van Kessel, 2018), which have increasingly shaken the very ground of the European project. At this point we find it timely to recall that the way in which European citizens could and should act is not to be defined by a competitive market policy and invoke the so-called European values of democracy and human rights, as laid out in the EU Charter.

Finally, we might well advocate that if a vision about the future of European citizens is to be imagined in the 21st century about how we want to create wealth and of what kind, this process would need to open up to wider audiences (Jasanoff, 2012). What kind of growth does the citizenry desire if growth is to be desired? What kind of innovation does the citizenry want if innovation is needed? These would be political and fundamentally democratic questions that at present would not be fully recognised as such in the European Union.

Chapter 3.

Case study: The roles of the innovations in (and for) nexus governance through the study of the European circular economy policy

Abstract

This chapter focuses on the role of innovation as imaginary in its interactions with the nexus and aims to develop a better understanding of how the circular economy policy is being (re-)shaped in a situation of crisis of legitimacy of the European project. Drawing on the taxonomy for analysis of technology by Allenby and Sarewitz (2013) and insights from ecological economics, we identify "innovation" as a central technical and political means to translate nexus concerns into win-win ideas posed on a level that is considerably different from the original nexus concerns. In this way, the innovations appear to solve a policy problem in the sense that they bring about win-win ideas at the discursive level in nexus governance. We argue that innovations are actions-oriented, and they pose the risk of failure across nexus sectoral domains, causing systemic failures across all policy levels involved. Simultaneously, the circular economy policy might be (re-)shaped in its early stages of formulation via this central role of innovation.

Key words: innovation, nexus, circular economy, complexity, governance

1. Introduction

Apparently disconnected from academic and political debates since the early 1970s on the difficulties of reconciling economic growth with the environment (Meadows et al.,1972; Gómez and Naredo, 2015), European policies have continued to announce the possibility of reconciling them via innovation, at least, since the launching of the EU2020 Strategy (European Commission, 2010a). Under this general political framework for the 2010s, several ambitious innovation-based political initiatives have been developed by announcing a reconciliation between economic growth and sustainability (European Commission, 2012, 2015, 2019b). In this chapter, we take issue with a particular policy—the circular economy policy—for which the European Commission has claimed to spend nearly 1 billion euro from Horizon 2020's final Work Programme (2018–2020) through research, innovation and financing projects (European Commission, 2017).

The concept of the circular economy officially entered the political European sphere in 2014 in the area of waste management (European Commission, 2014d), borrowing a particular vision of "circularity" from the Ellen MacArthur Foundation (Kovacic et al., 2019). Later, the concept was expanded to cover a whole economic cycle of production, consumption, waste management and secondary raw materials (European Commission, 2015). In 2017, the circular economy was proposed for building an economy where "growth no longer requires an increasing extraction and consumption of resources, energy, water and primary raw materials. There is less waste, and products and resources maintain their value in the economy for as long possible" (European Commission, 2017:4). Within this vision, so-called "recycling innovations" are expected to play a key role by, for instance, using waste to produce fuel.

In this chapter, we are not concerned with the specific content or the definition(s) of the circular economy policy. Rather, this policy will be understood as a process in which the meaning is built interactionally and co-constitutively (Clark, 2005) with difficult nexus tradeoffs in a situation of legitimacy crisis of the European project and the negotiation of different economic and political interests (Kovacic et.al, 2019). At this level of collective meaning-making of this policy, we will critically investigate the role of the innovation imaginary in (re-)shaping it through its interactions with the nexus.

For this purpose, we shall critically analyse 14 innovations (from 14 EU-funded projects that have been selected by the European Commission itself as main drivers of the circular economy, European Commission, 2017) through the combination of two theoretical lenses: a taxonomy developed by Allenby and Sarewitz (2013) and theoretical knowledge from ecological economics (Giampietro et al., 2014, 2017) (Giampietro, 2018, 2019). First, we use Allenby and Sarewitz's terminology to argue that innovations play a very specific role in (and for) nexus governance. We shall complement this terminology with theoretical knowledge from ecological economics as an approach that points to tensions and nexus tradeoffs to critically assess the potential implications of the innovations (before they are implemented) *for* the nexus. Both critical assessments have a didactic purpose: to develop a better understanding of the role of innovation (as imaginary or idea) in its interactions with the nexus, so that such interactions might contribute to the (re-)shaping of the circular economy policy.

The chapter is structured as follows. In section 2, we provide a more detailed overview of the theoretical lenses applied and the research questions raised to assess the innovations selected by the European Commission itself. In section 3, we spell out the methodological process as well as the specific materials used in this assessment. In section 4, we bring the results of the overall assessment in a synthesised format. In section 5, we discuss them by reflecting on the role of innovation (as imaginary) in their interactions with the nexus and by drawing on some lessons learned in chapter 2. We will end with some concluding remarks on how the circular economy policy is being made and might be (re-)made in a situation of legitimacy crisis of the European institutions.

2. Theoretical framework

In this section, we shall introduce the theoretical framework and the subsequent specific research questions deriving from these theoretical lenses to assess the innovations that are supposedly the main drivers of a circular economy. As for the theoretical framework, we have drawn on Allenby and Sarewitz's (2013) theoretical taxonomy together with critical insights from ecological economics (Giampietro et al., 2014, 2017) (Giampietro, 2018, 2019). On the one hand**,** Allenby and Sarewitz (2013) distinguish three levels through which a technology interacts and co-evolves, the boundaries of which are often fuzzy:

- *Level I technology* is the technological solution itself. When viewed at this level, the effectiveness of technology depends only to a small degree on the larger organisational setting and captures the cause–effect of a particular task very well. For instance, a strike at airport security control might prevent an airplane from departing, but the airplane itself as a Level I technology is still very effective in getting from one place to another.
- *Level II technology* is the larger sociotechnical and institutional system required to put the technology to work. This level includes security systems, networking, infrastructures, transport systems, companies, food supply systems, energy, water, workforce, legislation, mentality, skills and so forth. To achieve a particular intended outcome is often difficult because internal system behaviour is more complex to predict and there is uncertainty about the future consequences of technological implementation. In this sense, the system is less governable in terms of achieving a particular outcome and the technological implementation can have multiple and unexpected consequences.
- *Level III technology* is better understood as the Global Earth perspective, that is, a highly complex, changing and adaptive system in which Level I technology, through Level II technology, interacts with other systems and affects socio-biophysical-ecological processes in ways that create emergent behaviours. The long-term behaviour of this system is even more unpredictable, incomprehensible and of radical contingency than Level II technology. Thus, achieving an intended outcome is even more difficult with a technological solution. This level is characterised by complexity and "wickedness" (for more detail about wicked problems, see Rittel and Webber 1973), and any solution to a wicked problem should be expected to create unanticipated (and often difficult) new problems.

Allenby and Sarewitz (2013) discuss several technologies in light of this taxonomy to illustrate the stalemate produced in the debate between the technological optimists on the human condition (so-called transhumanists) and their critics. These technologies range from the airplane, car or synthetic biology to those that appear at the core of the transhumanist agenda (e.g., vaccines, cochlear implants or devices for military operations). These authors argue that the control domain promised by many of these technologies will be limited to Level I technology, that is, the goal that the technological fix actually addresses is different from the more complex Level II or III goals. On the other hand, as long as these technologies are implemented on a larger scale, they might introduce higher complexity to sociotechnical systems by producing undesired collateral effects and conflicting with Level II goals or by introducing dynamical behaviours at Level III. Therefore, any meaningful discussion of a technology must emphasise its transformative role at Level II and III (also coined as a destabilising role). In this way, according to Allenby and Sarewitz, technological optimists will tend to disregard problems and conflicts that emerge at Level II and Level III and will tend to make a category mistake by proposing Level I solutions for Level II or Level III goals (or problems). In other words: "we inhabit Level III, but we act as if we live on Level II, and we work with Level I tools" (Allenby and Sarewitz, 2013: 161). For instance, there has been little progress in decreasing global CO_2 emissions due to the category mistake of Level I solutions (e.g., solar panels, wind turbines, etc.) in a Level III world. However, social and policy solutions are also seen by these authors as tending to fail since they are more difficult non-technological solutions that are ineffective in dealing with Level II and Level III problems.

Given the wide range of technologies that can be discussed in light of this theoretical taxonomy, we have found it very useful and didactic to apply it to assess the innovations that supposedly support the transition to a circular economy. Accordingly, we have translated this taxonomy into four specific research questions shown in Table 1 at the end of this section. In raising these questions, we have also found it appropriate to employ the concept of *sociotechnical imaginaries* (Jasanoff and Kim, 2009). In this sense, the circular economy policy is understood as being shaped through sociotechnical imaginaries, that is, hypothetical projections toward the future that announce the reconciliation of economic goals and environmental concerns by joint efforts from researchers, technology centres, industry, entrepreneurs, civil society and governments (European Commission, 2017:4; Kovacic et al., 2019). And within these imaginaries, innovations are expected to play a key role by supporting that normative future state. Indeed, attempts can be made to materialise and implement the imaginaries of innovation through priorities of policy areas of research. In the case of the innovations selected for a circular economy, they are mainly in the testing phase, pilot studies or experimentation at the laboratory level.

Finally, we have complemented Allenby and Sarewitz's taxonomy with insights from the academic tradition of ecological economics (Giampietro et al., 2014, 2017) (Giampietro, 2018, 2019). Specifically, we have drawn a parallel between Level III (the level we inhabit, which is characterised by "wicked" complexity and uncertainty) and the nexus. In what follows we shall explain this parallel and introduce a fifth research question in our analysis to further assess Level III potential implications of the innovations *for* the nexus.

Thinking about the (biophysical) nexus implies thinking about the biophysical interconnections between water, energy and food that can stabilise the functioning of socio-ecological systems (Giampietro et al., 2014, 2017) (Giampietro, 2018). Thinking about the nexus also implies speaking about the tensions and tradeoffs between economic growth and sustainability, the need to respect the integrity of natural cycles, and the regeneration and maintenance of biophysical resources (Giampietro, 2019). In more technical words, sustainability and nexus issues call for compatibility between the size and pace of societal funds operating in the technosphere, and the size and pace of ecological funds in the biosphere (Giampietro, 2019: 148).

The concepts of technosphere and biosphere come from the reconceptualisation of the relation between economic systems, natural biophysical flows and entropy creation (Kovacic et al., 2019). Indeed, the latter concept is one of the key insights into ecological economics that comes from the implications of the second law of thermodynamics (Georgescu-Roegen, 1971). Economic systems, as well as ecosystems, societies or living organisms, create order which is accompanied by a process that creates even more disorder through dissipation. In economic systems, raw materials are transformed into highly ordered objects by using ordered structures of natural stocks or by using some high-order form of energy such as electricity to organise the raw materials in the desired way. Roughly, in all these processes, there is a creation of disorder through dissipation: whenever chemical, mechanical or electrical energy is used, some part will be converted into heat, which is a disorderly form of energy that cannot be converted without additional energy cost (and new materials). Thus, the technosphere is more specifically defined as a dissipative structure under human control in which a set of secondary flows (e.g., water, energy, such as electricity or gasoline, raw materials and food) are at the same time inputs and outputs produced and consumed. These flows come from primary resources provided by the biosphere (e.g., wind, fossil energy reserves, coal mines, aquifers, rivers, fertile soil) (Giampietro, 2019). The technosphere also creates wastes and emissions (primary sinks), so that primary sinks and primary resources are primary flows that cross the interface between the technosphere and the biosphere. An additional key distinction within these concepts is the use of non-renewable and renewable resources. The former implies that the stock is diminished as long as the flow goes out of stock and the second implies that the resource (also called ecological funds[9]) can produce or consume flows without necessarily changing their integrity (e.g., a river can clean a certain amount of polluted water).

Overall, the challenges of sustainability and the nexus would entail ensuring that those funds (e.g., aquifers, soil or biodiversity conservation) are reproduced, protected and maintained and not compromised by the dissipative technosphere. If ecological funds collapse and exceed their carrying capacity, the resources then become non-renewable and will ultimately constrain economic activities (in the very long term their own survival) (Giampietro, 2019).Thus, the challenges of sustainability and the nexus would also involve slowing down the pace of the fast-growing economic activities in our societies which, since the industrial revolution, (a) have dramatically increased the flows of energy and materials based on a linear exploitation of non-renewable stocks of fossil energy and (b) stressed ecological funds such as soil health or biodiversity. Indeed, from this perspective, a circular economy would be similar to those pre-industrial economies in which the mode of energy and food production was based on circular fund-flows, that is, the pace and density of flows throughput was constrained by the capacity of ecological funds to produce renewable primary sources and absorb waste and emissions (Kovacic et al., 2019).

If we compare this perspective of ecological economics with Level III in Allenby and Sarewitz's terminology, we observe that the complex interplay between the technosphere and biosphere (which enables us to think about nexus tradeoffs and the tensions between sustainability and economic growth) resembles, to a certain extent, Level III (the complex, changing and adaptive system in which Level I technology, Level II and socio-biophysical-ecological systems interact in the long term). The application of this parallelism will allow us to critically develop a better understanding of the role of innovation in (and for) nexus governance. In the table below, we present the research questions following the theoretical considerations mentioned above:

Table 1. Research questions to assess the innovations

Level I: Innovations selected for a circular economy. 1. What are the technological or policy solutions selected?	**Among the innovations, are there patterns of interactions between Level I,**
Level II: Descriptions and problems of these innovations. 2. In the policy process, are there considerations of Level II problems? What kind?	

[9] Societal funds inside the technosphere, such as the work force, land use or technologies, are also capable of both producing and consuming flows (Giampietro, 2019).

3. If there is already a record of results of Level I performance and Level II collateral effects, contrast it with the expectations associated with the original goal.	**Level II and Level III (nexus)?**
Level III (nexus) implications of the innovations 4. Are there considerations about potential Level III implications of the innovations? 5. From the ecological economics perspective, what could we say about (some) potential implications for the nexus of a large-scale implementation of these innovations?	

To address the fifth research question, we shall specifically draw on a third category of flows distinguished in the socio-ecological systems*: tertiary flows* (Giampietro, 2019: 152). Tertiary flows derive from recycling flows such as waste or CO_2 emissions, which are considered secondary flows since they will be consumed inside the technosphere before they cross toward the biosphere as primary flows. Many innovations selected for a circular economy are along the lines of recycling, re-(using) and/or valorising these secondary flows (waste, pollutants, etc.), in order to reinsert the outputs in the economic processes. We will therefore assess some of the potential implications of these innovations *for* the (biophysical) nexus. Specifically, we will suggest potential tradeoffs created for the nexus and potential implications in terms of the relation between the primary flows (primary sources and primary sinks) required by the "recycling innovations" inside the technosphere and the availability of primary flows in the biosphere both on the supply and sink side. The purpose of this research question is also to explore the type of work this critique might do within the predominant role(s) that innovation plays in its interactions with the nexus.

In the following section, we will describe how we have applied the research questions and the specific materials used.

3. Methodological process

Before applying the research questions introduced in the previous section, we first conceptualised the sociotechnical imaginaries embedded in the circular economy policy. For this purpose, we identified the projections portrayed in the seven areas of research and innovation policy selected by the European Commission as "already supporting the transition to a circular economy through projects" (European Commission, 2017:5). These imaginaries are summarised in Table 2 (see section 4 of Results).

We then collected information about each of the 14 selected EU-funded projects (two projects in each area of R&I policy and funded under the Seventh Framework Programme and the Horizon 2020 Programme) in order to apply the research questions. For each project, we collected the following information from their websites: project deliverables, scientific publications uploaded to the websites, information displayed about project topic, news disseminated and weblinks of blogs related to the project. Additionally, we consulted the public repository CORDIS,[10] which contains project results (project factsheets, final report summaries, deliverables, etc.), especially in cases for which no website was available (e.g., the ECO2CO2 project) or public content was scarce (e.g., the LIMPID project). Content analysis was also subject to the saturation criterion, a key concept within qualitative methodological approaches (Creswell, 2014), by which further analysis of contents no longer sparks new insights in response to the research questions. At the time of writing this chapter, all 14 projects had been completed.

For each EU-funded project, we systematically performed the following analytical steps: first, we briefly describe the particular goals and imaginaries. Secondly, we address the first research question by identifying the specific technological or policy solution (Level I technology). For research question two, we track whether Level II problems are considered and what kind. It is important to note here that most of the EU-funded projects deal with problems at Level II (e.g., high investments and economic costs, energy consumption, water consumption, legislation frameworks, etc.) when running technological testing and research experiments in the laboratory and performing pilot experiments of the innovations proposed. In this way, we summarise the descriptions of these Level II problems (considered during testing and pilot phases) and other more general Level II problems considered. In addition, we indicate some of the solutions and remedial actions proposed on how to overcome them.

For the third research question, we have checked whether there is a record of results of Level I performance, and if so, we have indicated if there is a good or modest performance at this level. For the record of results of Level II collateral effects, first we checked if there is a larger-scale implementation of the innovations. For the fourth research question, we tracked whether Level III problems are considered in each EU-funded project and what kind. In those cases, we summarised the descriptions of the Level III problems identified. Finally, for the fifth research question, we iterated this question for all the innovations proposed within each project. The details of these analytical steps are shown in Appendix 1, which contains 14 tables that correspond to the critical assessment of each EU-funded project. The specific references that appear in each table are listed in Appendix 2.

[10] Available at: https://cordis.europa.eu/projects/en

Finally, the results are displayed in two main tables in section 4 of Results (Tables 3 and 4). Table 3 lists the area of R&I policy, the respective EU-funded projects selected by the European Commission within each area, and the specific technological and policy solutions proposed within each project (Level I technology). The results of the rest of the research questions (two, three, four and five) are given in a comprehensive table (Table 4), according to a qualitative assessment scale (see Table 4.1 in the Results section). This scale has been devised as follows. For the second research question, we collated the results according to two main assessment criteria: a) the grade of consideration given to Level II problems (usually called "barriers", "limitations", "obstacles" to implementation of the innovation) in relation to the overall expectation associated with the original goal of the EU-funded project (criterion 2.1). Three simple categories have been assigned for this criterion: "none or minor consideration", "few problems are considered" and "several problems are considered". In addition, we have indicated if those Level II problems (in the different categories) are considered in the documentation and are expected to be overcome (criterion 2.2). For the third question, we collated the results according to two main criteria: a) the Level I performance assessed under the categories "good" or "modest" (criterion 3.1) and b) verification of a larger-scale implementation of the innovations according to the following three categories: "there is no larger-scale implementation", "modest scaling up" and "scaling up in several European regions" (criterion 3.2). For the fourth research question, we collated the results according to two categories, which have been assigned in terms of the consideration given to Level III problems within the overall expectation associated with the project goal: "none" or "minor consideration". Finally, for the fifth research question, we collated the results according to one simple category, which points to potential nexus tradeoffs and biophysical costs that would be associated with the larger-scale implementation of the innovations analysed.

In the following section, we display the results of the analysis in the respective Tables 2, 3 and 4 mentioned above. These results will be discussed in section 5, where the main argument of this chapter will be developed.

4. Results of the critical assessment

In Table 2 below, we summarise the sociotechnical imaginaries (and the specific goals) portrayed in the seven areas of R&I policy, which are pointed out by the Commission itself as "already supporting the transition to a circular economy through projects" (European Commission, 2017:5).

Table 2. Sociotechnical imaginaries of the circular economy policy

Area of R&I	Sociotechnical imaginaries

Catalysis	Developing catalytic technologies that speed up chemical reactions to (1) eliminate pollutants and (2) turn waste CO_2 into chemicals for industry and agriculture. These technologies are expected to contribute to decarbonise industry.
Industrial biotechnology	Developing enzymes and micro-organisms to (1) biodegrade plastics to produce bio-based plastics and (2) transform raw materials such as agricultural products, organic waste or plant biomass into useful goods such as fuels, chemicals or feed. These "white technologies" would allow companies to continue growing while generating less waste and less dependence on non-renewable resources.
Sustainable process industry	Developing new technological processes (1) to use non-renewable resources more efficiently (e.g., new energy-saving processes) and (2) to increase the use of renewable sources (energy and raw materials) to decouple growth from the scarcity of non-renewables and to reduce fossil dependence.
Waste and resource management	Developing measures and tools such as secondary raw materials inventories, waste databases and building design protocols, to improve the management of waste and resources. A key insignia of the circular economy is that one industry's waste would become another's raw material.
Closed-loop manufacturing systems	Reincorporating materials contained in products (considered waste and old products) into production processes by using, repairing and recycling them. Thus, the value of products and materials is maintained in the economy for as long as possible; waste is minimised, and business opportunities are created.
Water in the circular economy	Facilitating water reuse in industrial activities through new and better water management systems that ensure enough good quality water. Thus, it is expected to reduce pressure on water supplies, create new business opportunities and keep industrial activities growing by using the water they need.
The circular bioeconomy	Avoiding waste such as food and unwanted fish catches and, ultimately, converting unavoidable fisheries and aquaculture residues, and other organic waste streams into food, feed, fibre, bio-based products or bioenergy. Thus, new business opportunities are also created and pressure on natural resources is reduced.

In Table 3 below, we list the EU-funded projects (by acronym and framework programme—FP7 or H2020) selected in each area of R&I policy, and the specific technologies and policy solutions proposed within these projects (Level I technology). For more detail about the goals and imaginaries of each EU-funded project, see Appendix 1.

Table 3. Level I technology

Area of R&I	EU-funded project		Level I: Innovations selected for a circular economy
Catalysis	LIMPID	FP7	1. Nanotechnologies for photocatalytic degradation of pollutants and bacteria both in air and in aqueous solution.
	Eco^2CO_2	FP7	2. Photocatalytic nanotechnology to convert CO_2 from a biorefinery into methanol.
Industrial biotechnology	P4SB	H2020	3. Tailor-made cell bacteria via synthetic biology to transform plastic waste into biodegradable plastic.
	BHIVE	H2020	4. Novel enzyme functions at the genome scale to better synthesise and convert biomass into different industrial applications (e.g., chemicals, materials and plastics)
Sustainable process industry	SHAREBOX	H2020	5. Digital platform to support decision-making about what resources (plant, equipment, waste, expertise, energy, etc.) can be shared between different manufacturing companies.
	MefCO2	H2020	6. Technology to synthesise methanol from CO_2 and hydrogen.
Waste and resource management	ProSUM	H2020	7. Digital database on secondary raw materials in Europe.
	BAMB	H2020	8. Datasets based on building materials suitable for recycling and building design protocol to enable disassembly, adaptability and reuse of building structural parts and materials.
Closed-loop manufacturing systems	RESYNTEX	H2020	9. Recycling approach and reprocessing technology to transform non-wearable textile waste into secondary raw materials.
	ResCOM	FP7	10. Analytical approach and software platform with several tools to support implementation of closed-loop product systems.
Water in the circular economy	ECOWAMA	FP7	11. Treatment of wastewater of the metal and plastic surface processing industry to recover a metal (nickel) and water, through electrically driven processes.
	R3Water	FP7	12. Set of technologies to optimise wastewater treatment plants into more efficient facilities that recover (1) clean water for reuse, (2) nutrients and (3) other valuable materials and energy sources.

The circular bioeconomy	DiscardLess	H2020	13. Analytical and mapping tools, online database and policy recommendations to gradual elimination of discards in European fisheries.
	REFRESH	H2020	14. Protocol, guidance, database, analytical IT tools to reduce food waste.

Table 4 shows the results of the critical assessment, in which the technological and policy solutions (Level I technology) are listed by the number assigned in the previous table. Below, Table 4.1 gives details of the assessment scale applied. For more details about the analysis of each innovation, see Appendix 1, which contains 14 tables on the critical assessment of each EU-funded project.

Table 4. Results of the critical assessment of the innovations selected for a circular economy.

Level I	Level II: Descriptions and problems of the innovations				Level III (nexus) implications of the innovations	
	2. In the policy process, are there considerations of Level II problems? What kind?		3. If there is a record of results of Level I performance and Level II collateral effects, contrast it with the expectations associated with the original goal.		4. Are there considerations about Level III potential implications?	5. From the ecological economics view, what could we say about (some) potential implications for the nexus of a large-scale implementation?
	2.1 Grade of consideration of Level 2 problems.	2.2 Check if Level 2 problems are expected to be overcome.	3.1 Level 1 performance?	3.2 Implementation at Level II?		
1	+	∞	✓✓	↑	x	!
2	+		✓	/	~	!
3	+	∞	✓	/	~	!
4	-		✓	/	~	!
5	++	∞	✓✓	/	~	!
6	+	∞	✓✓	/	~	!
7	+	∞	✓✓	/	~	!
8	++	∞	✓✓	/	~	!
9	++	∞	✓	/	~	!
10	++	∞	✓	/	~	!
11	+	∞	✓	↑	~	!
12	++	∞	✓	/	~	!
13	++	∞	✓	↑↑	~	!

14	++	∞	✓	/	~	!

Table 4.1. Assessment scale

Research question	Categories	
2.1	-	No consideration
	+	Low
	++	Low-medium (several problems are considered)
2.2	∞	Problems considered are expected to be overcome through diverse solutions and remedial actions
3.1	✓	Modest performance
	✓✓	Good performance
3.3	/	There is no larger-scale implementation
	↑	Modest scaling up
	↑↑	Scaling up in several European regions
4	~	No consideration
	x	Minor consideration
5	!	Biophysical costs and tradeoffs for the nexus

5. What lessons can be drawn from this critical assessment?

In this section, we shall address the final cross-cutting question: among the innovations, are there patterns of interactions between Levels I, II and III (nexus)? Specifically, the section is split into two subsections. In the first, we shall draw on some lessons learned from Chapter 2 and discuss the results from research questions one, two, three and four. In the second section, we shall discuss the results from research question five.

5.1 Lessons from research questions one, two, three and four

In the critical analysis of the EU2020 discourse developed in Chapter 2, we argued how this discourse is posed within a neoliberal political rationality aimed at expanding economic growth and relaunching the "single European market" in a crisis of legitimacy of the European project. Specifically, in nexus governance, we argued that the innovation enables nexus tradeoffs to be translated into a discourse of imagined win-win solutions (for the environment, and for the economy and market-making). For instance, electrical cars were primarily envisioned as reducing greenhouse gas emissions and thus as "eco-friendly or clean" (if electricity is produced from renewable energy sources)—and also, as marketable "cars". At the policy discourse level, the innovation-based circular economy policy *also* embraces a set of sociotechnical imaginaries from different areas of research and innovation policy that broadly purport to reconcile economic goals (keeping economic growth on track, creating new jobs and competitive businesses) with environmental concerns and sustainability issues (see Table 2 above). Specifically, if we compare the innovations selected for a circular economy (see Table 3 above on Level I technology) with the goals and imaginaries of each EU-funded project (see these goals in Tables 5–18 in Appendix 1), we can observe a pattern in all the innovations: they are primarily introduced as win-win ideas (for the environment and the economy), which are mainly embodied into technical objects and processes. Below, we show this point for each innovation selected:

- *Innovation 1:* the photocatalytic nanotechnology is seen as (1) eco-friendly because the degradation process of pollutants appears "clean" by using solar energy instead of fossil energy sources, and (2) as a business opportunity because the technology is expected to be developed in several applications (e.g., self-cleaning coating to be deposited onto large surfaces of buildings), which might save on the cleaning costs of large surfaces of buildings.
- *Innovation 2*: the photocatalytic nanotechnology is envisioned as (1) eco-friendly because it would reduce CO_2 emissions released from industrial processes by capturing them to produce a versatile chemical such as methanol. This production process also uses renewable energy (through the photocatalytic feature) instead of conventional energy such as non-renewable fossil energy. Simultaneously, the innovation is seen as (2) a market opportunity for the industrial sector because methanol will be used for several industrial applications (e.g., perfume, fragrances, flavourings or adhesives).
- *Innovation 3:* the genetically engineered bacterium via synthetic biology is projected as (1) environmentally friendly because plastic would be produced by degrading and metabolising oil-based-plastic waste (especially that which is not recycled or burned to produce energy and mostly ends up in landfills or in the environment) instead of oil inputs, and because the plastic produced would also be biodegradable. Simultaneously, the innovation is seen as (2) a business opportunity for industrial sectors because the plastic obtained can be used for many applications.
- *Innovation 4:* the novel enzymes at the genome scale are envisioned as (1) eco-friendly because they synthesise and convert biomass (from agricultural residue, forestry products and food waste) to produce materials, plastics or textile instead of using fossil-fuel energy as the main input. Simultaneously, the innovation is seen (2) as a business opportunity in forestry and agricultural sectors because these plastics and materials can be used for several commercial applications.
- *Innovation 5*: the digital platform is announced as (1) environmentally friendly because it would reduce CO_2 emissions, fossil dependence, dependence on natural resources and waste streams by supporting sharing resources between manufacturing companies (e.g., waste to recover energy) and by using non-renewable resources more efficiently. Simultaneously, the innovation

is announced as (2) an economic opportunity for the industrial sector because, for instance, it saves productions costs through sharing resources such as plants, equipment or expertise between manufacturing companies.

- *Innovation 6*: the technology to synthesise methanol from CO_2 and hydrogen is seen as (1) environmentally friendly because it captures CO_2 released into the atmosphere and because the water electrolysis that generates hydrogen will use surplus electricity from renewable energy. The innovation is also seen as (2) an industrial and market opportunity because the technology is capable of producing methanol as an alternative fuel.
- *Innovation 7:* the digital database is seen as (1) eco-friendly because it performs extensive measurement of large amounts of secondary raw material waste to recycle them in the future, thereby reducing the extraction of (virgin) raw materials, and as (2) a business opportunity since the recycled raw materials would be (re)inserted into manufacturing processes.
- *Innovation 8:* several tools and building design protocols are announced as (1) "eco-friendly" because they would reduce a) the extraction of primary raw materials for buildings and b) the generation of demolition waste, through recycling and reusage of building materials and keeping new constructions for as long as possible in the technosphere. The innovations are also seen as (2) a business opportunity for the building sector.
- *Innovation 9*: the reprocessing technology is seen as (1) environmentally friendly since it would reduce dependence on resources extraction by recycling unwearable textile waste to generate a specific set of secondary raw materials (e.g., bioethanol) and (2) as an industrial opportunity since the end-products generated are useful for several industrial applications.
- *Innovation 10:* the approach and software platform with several tools are seen as (1) environmentally friendly because they would reduce pressure on the extraction of raw materials by supporting the repair, maintenance and reuse of materials and components of products such as baby strollers or washing machines. The innovations are also seen as (2) a business opportunity for the manufacturing processes.
- *Innovation 11:* the treatment of wastewater of the metal and plastic surface processing industry that recovers water and nickel through electrically driven processes is seen as (1) eco-friendly because it would relieve pressure on water scarcity, avoid the expensive disposal of wastewater containing nickel, relieve the extraction of nickel (scarce raw material) and save electrical energy since treatment simultaneously produces hydrogen that will be used to feed fuel cells that generate electricity. The innovation is also seen as (2) a business opportunity since nickel is a highly valuable metal on the market.
- *Innovation 12*: the set of technologies that optimise wastewater treatment plants are seen as (1) eco-friendly because they would relieve pressure on water scarcity by recovering water and as (2) a business and industrial opportunity since the plants also recover valuable materials, nutrients and energy sources.

- *Innovation 13*: the database, manual, processing solutions, mapping tool and policy recommendations are seen as (1) environmentally friendly since they would relieve pressure on the natural resource of fish stocks by first avoiding bycatch and (2) as an economic opportunity by transforming unavoidable bycatch into other valuable resources such as vitamins.
- *Innovation 14:* the framework, protocol, database, analytical IT tools and policy recommendations are seen as (1) environmentally friendly because they would reduce pressure on natural resources by avoiding food waste and greenhouse emissions by optimising the utilisation of resources within the food system and (2) as a market opportunity by transforming unavoidable food waste into other resources.

In this iterative exercise, we find a different kind of nexus concerns and environmental tensions involved in all innovations and these concerns are derived from economic and industrial activities (e.g., dependence on non-renewable fossil energy sources, CO_2 emissions that aggravate system problems such as climate change, the generation of different types of wastes, the pressure on the extraction of raw materials and natural resources such as water sources, etc.). These concerns are also nexus concerns belonging to Level III, and the innovations are primarily introduced as win-win ideas *at Level I technology.* To summarise **our first point**, in the governance of nexus concerns and difficult tradeoffs (belonging to Level III), innovation is about working more specifically as a central technical means to translate different types of environmental nexus concerns into diverse win-win ideas and imaginaries at Level I technology.

As for the results of research question two, most EU-funded projects deal with problems at Level II (e.g., investments, energy consumption, infrastructures, legislation frameworks, etc.) when running the technological testing and research experiments on a laboratory scale and performing demo-scale pilots of the innovations proposed. Specifically, the results (see criterion 2.1 in Table 4 above) reveal that in Innovation 4, Level II problems are not considered at all, and in six of them (i.e., 1, 2, 3, 6, 7 and 11), general Level II problems are barely considered in relation to the promises and expectations delivered in the reports, scientific papers and other content published on the projects' website. In the rest of the innovations (i.e., 5, 8, 9, 10, 12, 13 and 14), the consideration of problems at Level II is higher. However, these problems are *not* described in terms of (a) a destabilising and messy role of innovations or (b) considerations of unpredictable collateral effects due to uncertainty about future consequences of larger-scale implementation (descriptions that Allenby and Sarewitz (2013) recommend emphasising for any technological or policy solution). Rather, the problems considered are usually called "barriers", "limitations" or "obstacles"—factors hindering the implementation of innovations on a larger scale. These so-called barriers include high investment costs (e.g., infrastructures), the operational costs of innovations (e.g., high electrical energy demand), significant chemical and water requirements, traditional mentalities and cultural attitudes anchored to linear approaches, inappropriate legislative frameworks, bureaucratic barriers, uncertainties in the data and so forth (for more detail, see the descriptions of Level II problems in Tables 5—18 in Appendix 1). At the same time, practically all EU-funded projects propose solutions, remedial actions and policy recommendations for overcoming the Level II problems considered (see criterion 2.2 in Table 4 above). Such remedial actions range from a) more technological development to produce and store energy from renewable sources and thus reduce CO_2 emissions during the functioning of the innovation, b) energy recovery from other alternatives such as solid waste, c) improving the efficiency rates of the technology, d) a change in mentality to embrace circular approaches (e.g., in building and product design), e) a new framework for actions and policy incentives in the form, for instance, of subsidies to f) improvements and optimisations of the technology at the testing stage (before it is implemented).

To summarise our **second point**, the innovations are proposed within each EU-funded project without giving much importance to their destabilising role at Level II. If Level II problems are considered, they are seen as barriers or obstacles that can be overcome optimistically with more technological fixes, optimisations and different policy solutions. Much less consideration is given to the unpredictable effects of Level III as shown by the results of research question four (see Table 4 above), where there is only a minor consideration in the EU-funded project LIMPID (for more detail, see Innovation 1 in Table 5 in Appendix 1). **Why?** Precisely, because the problems and (nexus) tradeoffs tend to be formulated at Level III of system problems, and the innovations are introduced as primary ideas or imaginaries at Level I, the effectiveness of which does not greatly depend on a larger organisation or their biophysical viability or feasibility *for* the nexus. In other words, the goals actually addressed by the innovations are *extremely different by degrees* from concerns and tensions (at Level III) deriving from economic growth and economic activities (e.g., climate change, greenhouse gas emissions, dependence on fossil fuels, waste generation, pressure on natural resources, etc.). In this sense, innovations can be seen as desirable ideas because they mainly fulfil a relatively simple function within the economy, a demand defined by a business enterprise or some other concrete human need. For instance, the economic need to produce fuel from a non-fossil source may be posed and this need is translated into a technical problem (e.g., Innovation 6 aims to synthesise methanol as an alternative fuel from CO_2 and hydrogen) and the problem is solved by making the technical object or process that carries the function. Innovations also make and order objects, improve and create changes in them (e.g., Innovation 2 incorporates photocatalytic features in high energy-demanding conversion processes of CO_2 into methanol; Innovation 12 optimises wastewater treatment plants) or make extensive measurements (e.g., Innovations 7 and 14 are based on digital databases of different types of waste to recycle and/or process them). In this way, the innovations, introduced as primary ideas at Level I, can also be seen as central technical means that enables attention to be directed at something specific in the face of the complexity of the nexus problems belonging to Level III.

Indeed, the relative success of these innovations can be confirmed in terms of criteria formulated as Level I technology**,** in which the technical object or process tends to work within the restricted domain of cause–effect for which it is designed and, thus, tends to be quite reliable in achieving the desired outcome. This is systematically confirmed in the checking of the record of results of Level I performance (see criterion 3.1 in Table 4 above), where five of the 14 innovations selected for a circular economy show a good performance at this level. The remaining innovations show a modest performance, which is expected to improve with further optimisation, and technical and policy solutions. Furthermore, relative success at Level I also facilitates the stabilisation of expectations of development and progress. The remedial actions proposed to overcome the so-called barriers that hinder innovation implementation can be seen as part of the actions that stabilise expectations of development.

In addition, it is interesting to highlight a specificity for the innovations selected for a circular economy: different types of waste (i.e., CO_2 waste, unwearable textile waste, water waste, sea residues, raw materials incorporated in products that end up as solid waste, building materials that can end up as demolition waste, etc.) are seen as resources or valuable inputs to be re-inserted in economic and industrial processes through recycling, conversion or valorisation. This pattern can be observed in all the innovations, except in Innovation 1, which does not involve the use of waste to be recycled or converted. Therefore, the ideas posed at Level I can be seen as desirable ideas because they are generally envisioned as environmentally friendly since they use different types of waste as inputs. Indeed, if some nexus tradeoffs are expected with these "recycling innovations", these nexus concerns are translated into further technical problems to be solved with additional technical fixes and improvements, which are incorporated within the scope of the innovations. This is specifically observed in Innovations 2, 6, 9, 11 and 12. Innovation 2 entails a concern about high energy-demanding conversion processes of CO_2 into methanol, which might generate more CO_2 than the CO_2 incorporated in the end product. Therefore, this concern is expected to be mitigated with the photocatalytic feature of the technology that harnesses solar energy. Innovation 6 involves a concern about the high electrical demand from the water electrolysis process to generate hydrogen (which, together with CO_2, will be synthesised into methanol). This concern is expected to be mitigated with the use of renewable energy within the scope of the innovation proposed. Innovation 9 also entails a concern about primary sources requirements (fossil energy, water consumption) from the recycling activity involved. This concern is expected to be lessened with additional technological fixes incorporated within the scope of the reprocessing technology (i.e., saving energy from valorisation of residual solid wastes and water from wastewater treatment). Similarly, Innovation 11 involves a concern about the high electrical energy consumption required by the wastewater treatment process. This concern is expected to be mitigated by feeding fuel cells that generate electricity with the hydrogen produced in electrically driven processes. Innovation 12 also entails a concern about the high electrical energy consumption required by conventional wastewater treatment plants and is expected to be mitigated with the optimisations incorporated in the various technologies proposed.

Furthermore, in the terminology of Allenby and Sarewitz (2013), we also observe that with system problems (in which it is practically impossible to achieve an intended outcome due to uncertainty about the future consequences of a technological implementation) it is not known whether the innovation works until the effect on the system has been measured and the causal effect has been verified. In this regard, by the time we finished our empirical assessment of the EU-funded projects (March 2021), all had been completed and, for most of them, there was no larger-scale implementation of the innovations as displayed by criterion 3.2 (see Table 4 above). Yet, the innovation-based discourse of the circular economy policy exercises power by functioning as a "politics of truth" (Lemke, 2001, 2002), that is, the EU-funded projects selected by the European Commission itself are discursively announced as "*already* supporting the transition to a circular economy" (European Commission, 2017:5), even though most of the innovations only exist as laboratory tests, prototypes and demo-scale pilots. As a result, the effect on the system cannot therefore be checked. That is, there is no record of results of Level II collateral effects which can be checked and contrasted with the original EU- funded project goals as put forward by research question three. Only Innovations 1 and 11 have been modestly scaled up, but there is no record of results of Level II collateral effects. As for Innovation 13, it has been further implemented in several European regions, and the project results show several problems emerging (so-called barriers) such as a reluctant mentality to embrace the landing obligation regulation. As for the record of results of Level II collateral effects, some members states, for instance, have reported that refusals to take observers onboard increased in 2017 (Fitzpatrick and Nielsen, 2019: 19) (for more detail, see results of research question two and three in Table 17 from Appendix 1). In general, the project results show very few changes in fishing practices in relation to the original project goals.

It is also worth mentioning that in terms of assessing technological upscaling, the concept of Technology Readiness Level (TRL) began to be implemented in EU-funded projects under the Horizon 2020 programme (Héder, 2017). When checking this feature in the specific H2020 projects selected by the European Commission (9 of the total 14 projects selected), we find that it is used, at least, in Innovation 3 (CORDIS, 2019a). Specifically, it is stated that the innovation “is now somewhere between TRL 3 and 5”, that is, not beyond the validation phase in the laboratory and relevant environment.

At the same time, the modest progress of the innovations formulated as Level I technology can indeed provide justification for their larger-scale implementation. In other words, the win-win ideas are translated into specific technical objects or processes that tend to work in the restricted domain for which they are designed, and this modest progress at this level promotes domains of extensive intervention and regulation (infrastructures, legislation, transport systems, etc.) to put the technological object or process to work. However, as Allenby and Sarewitz (2013) would argue, that these innovations fail at solving Levell III system problems would not be surprising. That is, the innovations could be expected not to achieve the original goals proposed in the EU-funded project (e.g., mitigate climate change), precisely because these goals (and concerns) belong to Level III of complex system problems and the goal that the technical object or process actually addresses is of a very different degree (i.e., Level I). Moreover, with system problems it would not be surprising that any imagined solution (at Level I) to a complex problem can create unanticipated new problems.

5.2 Lessons from research question five

As for research question five, from an ecological economics perspective (Giampietro, 2019) we assess some potential biophysical tradeoffs for the nexus that might be created by a larger-scale implementation of the innovations. Specifically, under this research question, innovations are understood mainly as technical objects and processes that aim to 1) recycle, reuse and valorise a set of flows metabolised inside the technosphere before they cross the border toward the biosphere as primary flows in the sink side (e.g., waste, greenhouse emissions) and 2) reinsert the outputs–flows in certain economic and industrial processes. In this way, we shall anticipate the pressure on the environment from these innovations, because they have not generally been implemented on a large scale. We therefore do not know the actual size of the primary flows required by them from the technosphere.

The results of the research question show that recycling innovations will tend to aggravate existing problems in other parts of the nexus, cause conflicts with other policy targets and/or cause (unintentionally) new and unexpected nexus tradeoffs which have not been anticipated (for more detail, see the analysis of this research question in Tables 5–18 in Appendix 1). In short, it would be quite doubtful to expand the innovations without additional biophysical costs. **Why?** Because the innovations proposed for a circular economy are *actions-oriented* and involve implicit priorities for the biophysical nexus. For instance:

- If waste (CO_2)-to-methanol technologies (exemplified by Innovations 2 and 6) were actually scaled up, in the long term they might discourage or conflict with policy targets that pursue a reduction of CO_2 polluting activities based on fossil-fuel energy because the innovation was made precisely to carry a specific economic function: to provide a type of versatile chemical such as methanol from CO_2 for the market. Thus, this policy target on CO_2-based methanol would be prioritised over others.
- If Innovation 3 (which announces the production of valuable inputs for industrial applications to generate economic benefits through the degradation of oil-based plastic waste via synthetic biology) were scaled up, in the very long term it might discourage or work against goals of preventing plastic waste generation because the innovation was proposed to produce several inputs for industrial application from this type of waste.
- If biomass deriving from forestry products-to-plastics technologies (e.g., Innovation 4) were scaled up, it might conflict with policy targets on land uses for agriculture. However, the biomass-to-applications policy target would be prioritised over agricultural policy targets because the technical innovation was made precisely to carry out a specific economic function: to provide s different type of outputs for several industrial applications from biomass.
- Similarly, if textile waste-to-raw materials technologies (e.g., Innovation 9) were scaled up, they might conflict with waste-to-energy policy targets. However, the textile waste-to-raw materials policy target would be prioritised because the innovation was made precisely to carry out a specific function: to provide raw materials for a set of economic activities.
- If food waste-to-resources technologies (e.g., Innovation 14) were scaled up, they might conflict with policy targets set by Innovation 4 for food waste-to-applications such as chemicals, plastics, materials or textiles. Both policy targets would be pursued simultaneously because both technical innovations were made to carry out their respective economic functions.

Thus, while at the level of the policy discourse win-win imaginaries are announced (and embodied into specific technical objects or processes at Level I technology), the priority *for* the biophysical nexus is already implicitly made. Because these win-win ideas at Level I are action-oriented, that implicitly makes some targets more viable than others. To sum up, we can outline a predominant role of the innovation imaginary in (and for) nexus governance thus far. In nexus governance, innovation enables the transformation of nexus concerns (Level III system concerns on the reduction of global emissions and waste, relieving pressure on natural resources, etc.) into a policy discourse of win-win ideas that tend to be formulated at Level I technology. At the same time, these ideas and imaginaries are actions-oriented and involve implicit priorities for the biophysical nexus. Consequently, the discourse of the circular economy policy contributes to the *formulation* of environmental concerns and tradeoffs for the biophysical nexus. Indeed, the results of research question 5 are not surprising since we already pre-established a resemblance between the nexus and Level III in Allenby and Sarewitz's terminology. In this sense, when innovations are posed as solutions at Level I for nexus problems that tend to be formulated on Level III system problems, these innovations could be expected to fail (with some uncertainty) at solving nexus problems in the material world (e.g., creating conflict with other parts of the nexus or unexpected new problems). Indeed, an insight from systems theory is that a system problem does not necessarily have a solution or fix at all (Kovacic, et al., 2020)

In the last part of this subsection, we briefly reflect on what might arise from performing critical analyses such as that undertaken under research question five within the predominant role of innovation identified so far. The innovations analysed under research question five are still virtually non-existent beyond prototypes, demo-scale pilots and laboratory tests. Hence, the critical analysis undertaken questions the potential lack of feasibility and viability in the biophysical sense before the innovations are actually implemented. In this sense, we observe that environmental concerns and nexus tradeoffs "flow back" into the policy space as a counter-narrative before the innovations have even been tested on a commercial scale. That is, the innovation-based discourse, with the help of these counter-narratives, contributes to the formulation of environmental concerns. On the other hand, the formulation of these concerns in the early stages of the meaning-making of the circular economy policy might lead to a re-think of this policy through the predominant role of innovation identified so far (that is, as a central technical means that enables Level III nexus concerns to be translated into ideas at Level I). In this last sense, we have introduced suggestions on, for instance, (1) what a proponent of the circular economy might reply to potential energy tradeoffs alerted by the counter-narrative of the ecological economics perspective and (2) what type of counter-narrative from this perspective could be (re)formulated. In this iterative exercise, we highlight an observed pattern in most of the innovations: the circular economy discourse can be (re-)shaped through innovation, as an imagined solution posed at Level I to the very nexus concerns formulated by these solutions and alerted by the ecological economics perspective (for more detail, see the analysis of research question five for Innovation 1 in Table 5 in Appendix 1, where this analysis is applicable for most of the innovations).

In the last section, we shall bring together the lessons learned in this section and shall conclude with some remarks.

6. Concluding remarks

In this chapter, we have developed a better understanding of the role played by the innovation imaginary in its interactions with the nexus that has profound implications in (re-)shaping overall

European policy frameworks such as the circular economy policy in a situation of severe crisis of legitimacy of the European project.

On the one hand, this policy is being shaped via innovation as the central political and technical means that enables the transformation of environmental concerns and nexus tradeoffs (that tend to be formulated at Level III complex system problems and are framed primarily as European concerns, e.g., dependence on fossil fuels, pressure on natural resources, etc.) into a discourse of win-win ideas formulated at Level I technology. In this way, in nexus governance, innovations (1) appear to solve a policy problem in the sense that they brought about ideas (at Level I) that promise "win-wins" at the discursive level and (2) facilitate the stabilisation of expectations of development and progress since Level I tends to be effective in achieving a desired outcome.

At the same time, innovations are actions-oriented and involve implicit priorities for the biophysical nexus. They would then run into nexus tradeoffs as long as they were implemented in the material world. That is, they would conflict with other parts of the nexus, introduce dynamical behaviours, and create unintended and unexpected new problems for the nexus. Thus, this type of policy framework that embraces a high number of applied fields across industries and sector domains might be seen as an increasingly risky political strategy because the innovations (as ideas embodied into specific technical objects or processes at Level I technology) could spread failure in one sectoral domain toward related domains, causing systemic failures across all implied policy levels.

Overall, from this diagnosis, the innovations selected for a circular economy are not connected to any change in the level of "circularity" of an economy. Instead, the only thing that could have been implemented in a situation of crisis of legitimacy of the European project is the concept of circular economy.

Furthermore, the overflow of environmental concerns (e.g., nexus tradeoffs, pressure on primary sources available in the biosphere) exposed by the ecological economics critical perspective before the actual large-scale implementation of the innovations might help the formulation of environmental concerns, to which the innovation-based discourse itself contributes. At the same time, such concerns might lead to a re-think of the policy in its early stages of meaning-making through the exercise of translation that innovation enables, that is, as technical means to translate environmental concerns (the outcomes of ideas posed at Level I) into a reformulated policy discourse of win-win ideas posed at Level I.

6.1 APPENDIX 1. CRITICAL ASSESSMENT OF THE EU-FUNDED PROJECTS

Table 5. Critical assessment of the FP7 project LIMPID (Innovation 1)

Goals and imaginaries:
To develop novel, cost-effective and safe nanostructured materials that use sunlight to degrade pollutants and bacteria in air or in aqueous solution and bring them into photocatalytic technological applications. These nanotechnologies are expected to be highly useful for a wide range of applications: wastewater treatment, potable water purification, pollutant degradation reactors, antibacterial treatment or self-cleaning coating to be deposited onto large surfaces of buildings. They would also require a reduced material usage in their assemblage and a reduced energy supply by harnessing solar energy. They are expected to contribute to a) make the environment cleaner and safer by improving the quality of air and water resources and b) to be of high commercial interest for industries (LIMPID, 2013) (CORDIS, 2016a).
Level I technology: Nanotechnologies for photocatalytic degradation of pollutants and bacteria
Level II descriptions and problems:
RQ 2: The project tested the photocatalytic activity of the nanomaterials and designed the most effective in several applications (e.g., pilot scale photocatalytic reactors, bactericidal films and self-cleaning coatings). In turn, these applications were tested by using pollutants such as pharmaceuticals and personal care products and endocrine-disrupting chemicals in wastewater and air pollutants such as oxides of nitrogen. The tests show promising results through increased stability and enhanced photocatalytic degradation compared with other commercial nanomaterials. At this testing phase, some problems have been identified: the cost of the overall process compared with other more cost-effective Advanced Oxidation Processes in Wastewater Treatment, plus the starting cost of assembling new nanomaterials to replace existing ones. These limitations could be overcome if, for instance, the new nanotechnologies are applied to specific water pollution problems which are poorly treated by current treatment plants. Another problem is that the intense colour in organic wastewater could impede light penetration. It could, however, be solved with a pre-oxidation step to reduce colour intensity and the time needed for photocatalytic activity. In addition, the results of the safety and risk assessment on the possible impacts of exposure to nanomaterials show little negative impact on human health or the environment.
RQ 3: The results at Level I technology show good **performance**. The project points out that several patents are already under submission for commercial development (CORDIS, 2016a), but there is no larger implementation of the technologies.
Level III (Nexus) implications of the innovations
RQ 4: In a final workshop, a speaker refers to studies on photocatalytic wastewater treatment that show a low rate of mineralisation, which suggests the formation of unknown transformation products (Yargeau, 2015:11). The speaker questions whether new problems are being created instead of solving existing problems.

<u>RQ 5</u>: The commercial production of nanomaterials (highly ordered objects) on a large scale will require high order forms of energy to produce such objects or to order the primary sources required in their assemblage (e.g., raw materials) in a desired way (even though reduced material usage is announced). A proponent of the circular economy might suggest that energy could be produced from renewable energy sources (e.g., extensive use of "clean" solar energy). From the ecological economics (e.e.) perspective, we should ask: which materials will be needed to produce those energy carriers? The proponent of the circular economy might suggest recycling raw materials with clean solar energy, but that would go back to the issue of the materials needed to produce those energy carriers. From the e.e. perspective, we learn that the creation of a new order through advanced technology is unavoidably coupled with processes of dissipation: whenever energy is used, a part will be converted into heat, which is a disorderly form of energy that cannot be converted without additional energy cost (and materials). Moreover, material flows lose qualitative features over time. Thus, material flows recycling might be done but to a certain extent and at a certain cost.

Table 6. Critical assessment of the FP7 project Eco²CO_2 (Innovation 2)

Goals and imaginaries:
To develop a low-cost photocatalytic technology capable of converting CO_2 from a biorefinery into methanol, a versatile chemical for the industrial production of perfume, fragrances, flavourings or adhesives. By mimicking photosynthesis and using water, this technology expects to contribute, non-negligibly, to the reduction of CO_2 released from industrial processes in Europe and simultaneously open promising and efficient routes for the industrial use of CO_2. The project expects to require less conventional energy by harnessing solar energy and generate less CO_2 than other high energy-demanding processes (CORDIS, 2016b).
Level I technology: Photocatalytic nanotechnology to convert CO_2 from a biorefinery into methanol
Level II descriptions and problems:
<u>RQ2</u>: The project tested whether methanol can be effectively produced in a more cost-competitive way than other processes that require considerable energy and generate more CO_2 than the CO_2 incorporated in the final product. Initial productivity targets in pilot reactors were partially achieved and some objectives had to be readjusted due to the need to increase safety and reduce large volumes of chemical waste during the testing phase. Another efficiency target is achieved at 80%. The project successfully proved that the technologies do not use expensive noble metals or materials, and that its techniques were amenable for mass production (CORDIS, 2016b). The project also considered factors that influence the larger scale implementation of the prototypes such as the potential worldwide methanol demand in the chemical industry or the conventional methanol price.
<u>RQ 3</u>: The results at Level I technology show **modest performance**. There is no larger scale implementation of the innovations, so there is no record of results of Level II collateral effects.
Level III (Nexus) implications of the innovations
<u>RQ 4</u>: No consideration of Level III problems.

RQ 5: (1) The implementation of nanotechnology on a larger scale might require a high demand of water in the conversion process and thus increase pressure on that primary resource from the biosphere. (2) The technological innovation is based on the use of CO_2 as an input before it crosses the border toward the biosphere as a primary sink. In the very long term, and in order to keep the conversion of CO_2 into methanol as a profitable industrial business, the innovation might conflict with or discourage policy targets that aim to reduce fossil fuel-based activities based that pollute with CO_2. (3) All the points developed in Innovation 1 about the mass production of this highly ordered technology are applicable here.

Table 7. Critical assessment of the H2020 project P4SB (Innovation 3)

Goals and imaginaries:
To design and genetically engineer bacteria via synthetic biology to transform oil-based plastic waste into biodegradable plastic. Specifically, bacteria would segregate enzymes that degrade reduced pieces of plastic waste into chemical counterparts which, in turn, would be processed (eaten) by the bacteria to metabolise and excrete ingredients for biodegradable plastic (P4SB, 2020). A major challenge is to prevent the plastic-eating bacteria from dying during the process, so that researchers can access the bioplastic contained within in a cost-effective way (RWTH, 2016). The project expects to reduce the environmental impact of plastic waste streams in Europe, converting them into inputs for a wide range of high-value applications such as children's toys, plastics bags, bottles, furniture or surgical implants (Gillman, 2016). It also expects to contribute to the EU2020 recycling targets, especially for those plastic wastes that are not recycled or burned to produce energy and largely end up in landfills or the environment. These "recycling innovations" are seen as key in the circular economy (Prieto, 2016) (Salvador et al., 2019)
Level I technology: Tailor-made cell bacterial via synthetic biology to transform plastic waste into biodegradable plastic
Level II descriptions and problems:
RQ2: The project results showed advances in the conversion process at the laboratory scale; however, it appears to be neither as cost-effective or profitable as current oil-based plastic production (Salvador et al., 2019) nor energy efficient (CORDIS, 2019a). The problem of energy efficiency is expected to be solved with energy produced free of CO_2 emissions in the future (CORDIS, 2019a) and with the degradation of plastics from monomers obtained from plant biomass (Salvador et al., 2019). Almost all foreseen and unforeseen risks were assessed and mitigated during the runtime of the project, that is, on the laboratory scale. Neither ethical nor societal risks are foreseen for these technologies (Kempchen et al., 2016).
RQ 3: The results at Level I technology show **modest performance**. There is no larger scale implementation of the innovations, so there is not record of results of Level 2 collateral effects.
Level III (Nexus) implications of the innovations
RQ 4: No consideration of Level III problems.

RQ 5: (1) The innovation is based in the use of oil-based plastic waste (secondary flows before crossing the border toward the biosphere and ending up in landfills) as a main input to transform it and produce biodegradable plastics (tertiary flow) for high-value applications. In the very long term, the economic goal of keeping this transformation (based on the use of oil-based plastics) as a profitable business might work against the goals of preventing and reducing the generation of oil-based plastic wastes. (2) The project itself indicates that the innovation is highly energy-demanding, but this is expected to be solved with "energy produced free of CO_2 emissions". From the e.e. perspective, we should ask: which materials will be needed to produce those energy carriers? In this case, that would go back to an issue raised in Innovation 1. (3) The proposal of the degradation of plastics with monomers obtained from plant biomass on a large scale might conflict with other biomass and land uses. The large-scale use of plant biomass might also impact on biodiversity. (4) All the points developed in Innovation 1 about the mass production of this highly ordered technology are also applicable here.

Table 8. Critical assessment of the H2020 project BHIVE (Innovation 4)

Goals and imaginaries:
To design novel microbial enzymes to better process the conversion of lignocellulose from biomass (e.g., agricultural residue, forestry products such as pulped trees or food waste) into high-value applications such as chemicals, plastics, materials or textile. Specifically, the project analyses genome sequences of microorganisms of plants that synthesise one of the most abundant sources—lignocellulose—and designs and develops novel enzymes to discover and identify proteins with entirely unknown relevant properties and functions that can better synthesise and transform lignocellulose into targeted end-products. In other words, the project seeks ways to extract value from biomass by mapping the "dark matter" of microbial genomes (CORDIS, 2019b). These novel routes expect to provide sustainable alternatives to plastics and other materials derived from fossil fuel by better harnessing renewable plant resources, as well as to create new business opportunities in the forestry and agricultural sectors (CORDIS, 2019b) (European Commission, 2015, 2019)
Level I technology: Novel enzymes at the genome scale to better synthesise and convert biomass into different industrial applications (e.g., chemicals, materials and plastics)
Level II descriptions and problems:
RQ 2: Several new enzymes were discovered and novel biocatalytic pathways were established in textiles and packaging materials. The project also characterised unclassified proteins with the ability to alter the architecture of cellulosic materials and established new functional screens to identify non-catalytic proteins that impact fibre porosity (Cordis, 2019b). The results of the metagenome sequences analysis at the laboratory scale have been mainly materialised in the publication of 21 academic papers (see, for instance, Razeq et al., 2018, and Mollerup and Master, 2016). In general, there are no considerations of Level II problems.

<u>RQ 3</u>: The results at Level I technology show modest **performance**. There is no larger scale implementation of the innovations, so there is no record of results of Level II collateral effects.
Level III (Nexus) implications of the innovations
<u>RQ 4</u>: No consideration of Level III problems.
<u>RQ 5</u>: (1) Biomass conversion into industrial applications such as materials or plastics uses sources such as agricultural residue, forestry products (e.g., pulped trees) and food waste as a main input. The larger scale implementation of this industrial activity (based on the use of food waste and agricultural residue) might compete with the policy target of waste-to-energy or the goal pursued by Innovation 14, which reprocesses food waste to produce marketable food products such as feed for pigs. (2) In the same way, the use of pulped trees as main inputs in this industrial activity on a large scale might involve changes in land use and might compete with agricultural activities. (3) In the long term, the size and pace of the sources required such as forestry products might stress the capacity of the primary renewable source to be regenerated and reproduced (e.g., soil depletion) or might have a negative impact on biodiversity (including irreversible biodiversity loss).

Table 9. Critical assessment of the H2020 project SHAREBOX (Innovation 5)

Goals and imaginaries:
To develop a digital platform to identify synergies in a network of manufacturing companies, so that they can share resources such as plants, logistics, equipment, energy, waste and emissions, recycled materials or even expertise across Europe. Through this software, plant managers could securely share information and data about what they have and what they need, and mathematical algorithms would help them to match the best resources, opportunities and partners with whom to cooperate and exchange. The project resembles the connections between companies as an optimum symbiotic ecosystem. In the long term, this "industrial symbiosis" aims a) to create economic value from waste and reduce costs by, for example, avoiding waste landfill costs, b) reduce consumption of fossil energy by, for instance, ranking options for energy recovery from waste and forming an industrial park between users with similar waste streams, c) reduce CO_2 emissions, d) save natural or fossil resources through recycled wastes that are considered potential raw materials and/or e) reduce inefficiencies (SHAREBOX, 2019a, 2019b). Industrial symbiosis is described as "the circular economy in action" (Lombardi et al., 2017:7).
Level I technology: Digital platform to support decision-making about what resources (plant, equipment, waste, energy, etc) can be shared between different manufacturing companies.
Level II descriptions and problems:

<u>RQ 2</u>: The project verified 17 synergies with industrial symbiosis (IS), showing economic benefits in terms of landfill diversion, carbon savings, increased sales and cost savings. As for the environmental benefits, 11 synergies were analysed and showed significant positive net savings in primary energy consumption, mineral resource use and greenhouse gas emissions (Itten et al., 2019). Several barriers for the large-scale implementation of IS are also identified (SHAREBOX, 2019a:19) (Woodcock et al., 2016): a) absence of trust between companies, b) informational barriers such as lacking quality and accurate resource data, c) risks and uncertainties derived from IS exchanges, d) technological transformations and adaptations to be undertaken before IS exchanges, e) increased inter-dependence and thus vulnerability, f) regulatory barriers across Europe that might prohibit the reuse or storage of materials deemed waste until permits are reviewed, g) cultural barriers such as resistance to change, h) spatial distance between companies, i) organisational barriers such as the time and will to implement IS, j) greater lack of financial resources in SMEs business, and/or j) long timeframe for implementation of solutions. The project also considers that certain policy interventions might hinder IS implementation. For example, a) fossil fuel subsidies might hinder the pursuit of renewable fuels and b) government investment in waste-to-energy would hinder the redirection of waste into other productive uses or a low level of landfill taxes would not support IS (Woodcock et al., 2016:8). In relation to the energy exchange, the project considers that storing electrical energy surplus and transporting heat energy might cost more than just buying primary energy. Additional bureaucratic barriers are new permits required to perform waste exchanges (Lombardi et al., 2017). The project tackles barriers such as informational and organisational ones by, for instance, programming a digital method to assess and share the operations total costs for "symbiotic exchange" among companies.
<u>RQ 3</u>: The results at Level I technology show **good performance**. There is no larger scale implementation of the innovations, so there is no record of results of Level II collateral effects.
Level III (Nexus) implications of the innovations
<u>RQ 4</u>: No consideration of Level III problems.
<u>RQ 5</u>: (1) Sharing and recycling raw materials are expected to be highly energy-demanding in the long term. That extra energy consumption might offset the net savings in the primary energy consumption announced. A proponent of the circular economy might suggest that energy could be produced from renewable energy sources, which goes back to the issue of materials needed to produce those energy carriers (issue already pointed out in Innovation 1). (2) Similarly, recycling waste for other uses than energy is expected to be highly energy-demanding. In the long term, even if such energy is produced with "clean solar energy", it again faces the issue of the materials needed to produce those energy carriers (point already developed in Innovation 1).

Table 10. Critical assessment of the H2020 project MefCO2 (Innovation 6)

Goals and imaginaries:
To develop a technology that produces methanol from captured CO_2 and hydrogen and stores it easily as a key alternative fuel. Specifically, hydrogen is extracted from water by electrolysis and mixed with the captured CO_2 to produce a methanol synthesis through a catalyst reaction. In turn, electrolysis is a high electricity consumer, so a mayor challenge is to extract hydrogen from water by using surplus electricity from renewable energy sources (wind, solar or hydroelectric power). The project expects to save on the use of fossil fuels since the methanol (as fuel) is produced by using CO_2 and hydrogen (as inputs), and the hydrogen is produced from surplus electricity from renewable energy and not from conventional fossil origins such as carbon or natural gas. In the long term, the project expects to contribute to a low carbon economy, the agenda on climate change and the creation of jobs (Mefco2, 2016a).
Level I technology: Technology to synthesise methanol from CO_2 and hydrogen, which is generated from water electrolysis using renewable energy.
Level II descriptions and problems:
RQ2: The project's consortium built a pilot plant to demonstrate the technical, economic and ecological feasibility. The pilot plant was technically able to produce 1 tonne of methanol per day by capturing 1.5 tonnes of CO_2 a day, although testing and validations in realistic working conditions have yet to be performed (Mefco2 2016a, 2016b). The amount of methanol produced in the pilot plant is small in relation to demand on an industrial scale and the project expects to improve efficiency rates in the long term (Mefco2, 2019). The production costs, mainly the electrical energy cost, is identified as a major handicap for large-scale technological development (Görner and Magistri, 2019). These costs would be addressed with more efficient technological development, growth in the commercial diffusion of methanol synthesis technology and government regulation to encourage so-called "low environmental impact" fuels. In addition, the transformation of the methanol supply system from fossil to renewable sources will use the existing infrastructures, thereby guaranteeing the security of the supply system (Mefco2, 2016c). The project considered several actions for large-scale commercialisation: mass production of electrolysers and modular CO_2-t-methanol systems, standardisation and capture-costs reduction for low concentration flue gas and policy incentives such as infrastructure subsidies (Stefansson, 2019). The project also considered the highly volatile power from wind and photovoltaics, which require cost-effective large-scale energy storage systems for the surplus of these energy sources (Koytsoumpa et al. 2016; Benesh and Kakaras, 2016).
RQ 3: The results at Level I technology show **modest performance**. There is no larger scale implementation of the innovations, so there is no record of results of Level II collateral effects.
Level III (Nexus) implications of the innovations
RQ 4: No consideration of Level III problems.

RQ 5: (1) If hydrogen is produced by electrolysis by using surplus electricity from renewable energy sources, we return to the issue of the type of materials needed to produce those energy carriers (already highlighted in Innovation 1). (2) All the points mentioned in Innovation 2 are applicable in this case: a) large-scale implementation of the technology might require high water demand and thus might increase pressure on that primary resource, b) the production of methanol (tertiary flows) depends on the use of CO_2 as an input. Therefore, in the very long term and in order to keep this industrial business profitable, the innovation might conflict with or discourage policy targets based on the primary goal of reducing CO_2 emissions. (3) All the points developed in Innovation 1 about the mass production of these highly ordered technologies are also applicable here.

Table 11. Critical assessment of the H2020 project ProSUM (Innovation 7)

Goals and imaginaries:
To develop a secondary raw materials digital inventory for Europe. Specifically, the digital database platform aims to better locate secondary raw materials such as gallium, indium, cobalt and aluminium, contained in vehicles, electrical and electronic equipment (EEE) and batteries (shown separately from the EEE and vehicles they come from) which are placed on the market, kept in-stock (in use and hibernated) and generated as waste flows. This "Urban Mine" Platform[11] aims to better provide a supply of raw materials contained in many products across Europe, which have been manufactured inside Europe, both with European and imported raw materials, or directly imported. The project expects to contribute to the circular economy by a) providing better access to these raw materials so they can be treated, recycled and (re)inserted in the manufacturing processes and b) reducing pressure on the consumption of virgin materials (Huisman et al., 2017).
Level I technology: Digital database on secondary raw materials in Europe
Level II descriptions and problems:
RQ 2: The project spelled out the data constraints, limitations and uncertainties involved in the data (e.g., in the computed quantities of materials and components of the waste products reported as collected, unknown waste and other waste, whose whereabouts are unknown such as those exported outside the EU (Huisman et al., 2017). The project also spelled out a set of recommendations to improve the database and increase materials recycling (Downes et al., 2027).
RQ 3: The results at Level I technology show good **performance**. There is no larger scale implementation of the innovation in the sense that the secondary raw materials accounted for in the digital inventory are not being recycled at large scale. Thus, there is no record of results of Level II collateral effects.
Level III (Nexus) implications of the innovations
RQ 4: No consideration of Level III problems.

[11] Available at: http://www.urbanmineplatform.eu/composition/eee/materials (accessed 22 July 2020)

RQ 5: (1) The large-scale implementation of the digital database aims to better locate secondary raw materials, so they can be recycled and (re)inserted in the manufacturing processes. The recycling of raw materials is highly energy demanding. A proponent of the circular economy policy might suggest recycling them with widespread clean solar energy, which would return to the issue already pointed out in Innovation 1. (2) The recycling activity on a large scale might involve other costs (e.g., the higher labour requirements might represent an opportunity cost since the labour available for more productive activities would decrease in favour of the recycling activities.)

Table 12. Critical assessment of the H2020 project BAMB (Innovation 8)

Goals and imaginaries:
To develop a set of tools for building materials to be reused again so that new (or renewed) building constructions can be kept for as long as possible in the technosphere (Hansen, 2016). These sets of tools are expected to drive the shift from a traditional linear approach to a circular approach in the building sector, which would have fewer environmental impacts (less generation of demolition waste and less use of virgin materials) (Bamb, 2016; Henrotay, 2016).
Level I technology: Datasets based on building materials suitable for recycling and building design protocol to enable disassembly, adaptability and reuse of building structural parts and materials
Level II descriptions and problems:
RQ 2: The project developed two main tools: "Materials Passports" (data sets on building materials characteristics and components suitable for reuse, reprocessing or recycling) and "Reversible Building Design" (a design protocol that reports on three criteria: disassembly of structural parts, building materials and components, and adaptability for similar or different applications). The tools were demonstrated in 6 pilot cases, which showed high prevention of waste generation and high reuse of raw materials over the course of several building transformations (Apelman et al., 2016). However, several barriers for implementing these tools have been identified: a) fragmented legislative frameworks such as urban regulations and building permits based on linear building visions; b) buildings that pursue high energy performance may result in designs and materials that do not lead to deconstruction and reuse; c) lack of robust and standardised data of the products and materials in the buildings; d) time-consumption involved in collecting data due to legal issues on ownership and data management; e) a conservative tradition of linear building models; f) a higher complexity in building disassembly than demolition; g) reversible building solutions perceived as too expensive due mainly to a short-term perspective; h) uncertainty about circular business models may dissuade suppliers from offering these alternatives, and i) little awareness about the advantages of reversible buildings (Apelman et al, 2016:76). To enable the transition toward a circular building environment, the project proposes long-term systemic changes through a "transition framework" (Apelman et al, 2016:82). The project also investigated business models of different reuse and recycling options, a software methodology to provide assessment in building designs about reuse and factors that might make an EU policy successful in driving a circular building sector.

RQ 3: The results at Level I technology show **good performance**. There is no larger scale implementation of the innovations, so there is no record of results of Level II collateral effects.
Level III (Nexus) implications of the innovations
RQ 4: No consideration of Level III problems.
RQ 5: (1) The raw materials (secondary flows) required by, for instance, "reversing building solutions" on a large scale, might need some high order form of energy that organises the raw materials in a desired way (e.g., high quality, durable, etc.). Such buildings might be more energy-demanding than other buildings that use conventional raw materials and not allow disassembly and reuse. Even if the energy can be produced with extensive clean solar energy (as a proponent of the circular economy might suggest), which materials would be needed to produce those energy carriers? (Issue already pointed out in Innovation 1.) (2) Similarly, raw materials might be recycled to a certain extent and at a certain energy cost because material flows lose their quality over time. (3) Building disassembly might have more labour requirements than demolition and might represent an opportunity cost as occurred with previous "recycling innovations".

Table 13. Critical assessment of the H2020 project RESYNTEX (Innovation 9)

Goals and imaginaries:
To design a conceptual approach and reprocessing technology to produce secondary raw materials from recycling unwearable textile waste, usually landfilled or incinerated. Specifically, the recycling approach involves several phases: a) textile waste collection, b) textile waste sorting and reduction of size, c) textile waste mechanical pre-treatment, d) chemical and biochemical process to transform different types of fibres (cotton, polyester, wool, silk and nylon) in intermediate products (e.g., glucose, ethylene glycol, polyamide oligomers), e) synthesis process of intermediate products to generate end-products for industrial applications: bioethanol, PET granulate, resin for adhesive wood and value-added chemicals. The project aims to include a thermal valorisation of residual solid waste to save energy (e.g., for heating and cooling requirements) and a wastewater treatment plant to save fresh water consumption. Overall, the project expects to create more circularity by reducing dependence on resources extraction since textile wastes are valuable inputs for generating secondary raw materials (Aneja et al., 2016; Nia et al., 2017).
Level I technology: Recycling approach and reprocessing technology to transform non-wearable textile waste into secondary raw materials.
Level II descriptions and problems:

RQ 2: The project evaluated the design concept by using life cycle assessment (LCA) and life cycle costing, showing that the chemical and biochemical process is the highest in terms of greenhouse gas (GHG) emissions, water withdrawal and life cycle costs, so further optimisation is needed. Specifically, bioethanol production showed higher GHG emissions than the reference system. Thus, among other solutions, the importance of selecting the right end product was highlighted (Pasquet, 2019). The project also developed a reprocessing line for basic textile components in a demo-scale pilot (Resyntex, 2019a). However, economic evaluation showed that efficiency is not enough to warrant investment in the plant. Positive profits would depend on a high selling price of the end-products, which is very unlikely to happen in the future, and losses would appear to be lower if, for instance, the waste textile is rich in polyester materials (Nikolakopoulos et al., 2017). Remedial actions are promoted by using concepts such as "industrial ecosystem" (Tyler and Hall, 2018) and "industrial symbiosis" (Nikolakopoulos et al., 2017, 2019), so the project proposes taking advantage of upstream flows and sharing downstream flows with other nearby plants (e.g., selling diluted glucose to nearby fermentation plants). An economic incentive by chemically recycled textile tonne could be a way of making investment more attractive. The collection of low-grade textiles presents an economic cost that could be more cost-effective through, for instance, policy incentives (e.g., landfill tax or fiscal incentives) or consumer involvement in the collection stage (Resyntex, 2019b). The requirements of energy, water withdrawal and chemicals by reprocessing technology together with GHG emissions (especially in the chemical and biochemical phase) need to be optimised for greater industrial development (Pasquet, 2019). Potential energy recovery and water treatment are some of the paths that will lead to further optimisation.
RQ 3: The results at Level I technology show **modest performance**. There is no larger scale implementation of the innovations, so there is no record of results of Level II collateral effects.
Level III (Nexus) implications of the innovations
RQ 4: No consideration of Level III problems.
RQ 5: (1) Large-scale textile waste reprocessing activity will require high volumes of secondary flows (energy, water and chemicals) and will generate CO_2 emissions (primary sinks). The proposal of a thermal valorisation to generate energy from residual solid waste might compensate, to some extent, the high energy demand. However, this proposal might create a conflict with the waste-hierarchy (e.g., the primary goal of preventing the generation of waste). (2) Wastewater treatment might also alleviate, to some extent, the pressure on this natural resource, but this is a high energy-demanding process. Using clean solar energy might be suggested, but that would go back to the issue of the materials needed to produce those energy carriers (issue pointed out in Innovation 1). Thus, to keep the recycling activity growing and profitable in the long term, the primary flows required will probably put pressure on the primary flows made available by the biosphere (both on the supply and sink sides). (3) In the long term, the goal of recycling textile waste (especially incinerated waste) to produce raw materials might conflict with the goal of recycling waste to produce energy. (4) The point developed in Innovation 1 about the mass production of a high order technology can be applied here.

Table 14. Critical assessment of the FP7 project ResCOM (Innovation 10)

Goals and imaginaries:
To develop an analytical approach to help industrial companies to design circular products and technological tools to implement closed-loop manufacturing business models (Lieder et al., 2017) (Bocken et al., 2016). Overall, the ResCOM framework and tools are expected to have more impact on the reduction of waste, energy and dependence on natural resources than current linear manufacturing systems, as well as to create new jobs (Rescom, 2016, 2017b).
Level I technology: Analytical approach and software platform with several tools to support implementation of closed-loop product systems.
Level II descriptions and problems:
RQ2: The project developed a generic methodological approach ("how to design a circular product") for companies to adopt closed-loop product systems (Bakker et al., 2017) and a software platform[12]. The latter contains several tools such as the "Circularity Calculator" that analyses data models in terms of resource efficiency, GHG emissions, energy and economic costs, and performs modelling iterations to find a desired closed-loop product system. The tools were verified in four case studies (Van Loon and Van Wassenhove, 2014): a) the first pilot tested the "Flex plan", which offers a leasing scheme for new *baby strollers*. Customers could change the model and accessories according to their needs. Used strollers are then returned and refurbished as "new". Tools such as the Circularity Calculator provided material volume saving; however, other tools showed contradictory findings. A number of barriers need to be addressed before implementation: setting up effective reverse logistics, tracking and tracing product returns, optimising design for durability and easier remanufacturing. b) The second pilot tested a service based in the leasing of *washing machines* for domestic customers, launderettes, hotels or cruise ships. Each machine would start as a new product (latest design) and would then be refurbished and offered twice until finally being removed and recycled. The tools showed the potential of the circular business model, for example, through a strategy for the interchangeability of parts, so each component could be designed and manufactured independently. However, the tools presented several challenges: reverse logistics, collecting customer payments, the need for an inventory of remanufactured washing machines, maintenance service and repairing costs. c) The third pilot investigated *TV design* for upgradability so that the latest features can be added to the product, rendering it functional for longer. The tools helped to specify which TV modules should be designed for reusing, upgrading and recycling, respectively, and the carbon footprint and overall operation costs were expected to be reduced. However, significant investment would be needed to improve current TV design and make it upgradeable. d) The fourth pilot investigated remanufacturing hydraulic rack and pinion *steering gears* for passenger cars and light commercial vehicles. The tools showed a positive economic and environmental performance in some scenarios, but major challenges included the high cost of acquiring used steering systems, poor transport conditions that can damage them and legislative barriers preventing the use of remanufactured parts in new vehicles (Rescom, 2017a).

[12]Available at: https://www.rescoms.eu/platform-and-tools (accessed 31 January 2021)

RQ 3: The results at Level I technology show **modest performance**. There is no larger scale implementation of the innovations, so there is no record of results of Level II collateral effects.
Level III (Nexus) implications of the innovations
RQ 4: No consideration of Level III problems.
RQ 5: (1) The materials and components that would lead to circular products (e.g., baby strollers) require some high order form of energy that organises these materials in the desired way (high quality accessories, durable, etc). On a large scale, these processes appear to be higher energy-demanding, and the use of clean solar energy might be suggested. However, that goes back to the issue already pointed out in Innovation 1 about the materials needed to produce these energy carriers. (2) Likewise, repairing, recycling and maintaining the functionality of materials and components of circular products could be done, but to a certain extent and at a cost in the long term. (3) Higher labour requirements for these closed-loop product systems might represent an opportunity cost at the expense of more productive activities.

Table 15. Critical assessment of the FP7 project ECOWAMA (Innovation 11)

Goals and imaginaries:
To develop a closed-cycle management model to treat heavily contaminated wastewater from the metal and plastic surface processing industry. Specifically, the project aims to combine the recovery of clean water for reuse with the recovery of a highly valuable metal (i.e., nickel) through different electrically driven technological processes. In addition, hydrogen produced during these electro-processes will be used to feed fuel cells that generate electricity and thus reduce the demand for electrical energy. Overall, this project announces a) high economic benefits due to the high market prices for nickel, as well as business opportunities, and b) prevention of environmental impacts by avoiding expensive disposal of wastewater containing nickel, relieving pressure on water scarcity and on the extraction of a scarce raw material such as nickel, and saving on electrical energy consumption since hydrogen is used to recover energy (Ecowama, 2016).
Level I technology: Treatment of wastewater from the metal and plastic surface processing industry to recover a valuable metal (nickel) and water through electrically driven processes.
Level II descriptions and problems:

<u>RQ 2</u>: The project built a wastewater treatment pilot plant and applied LCA to assess the environmental impacts in categories such as climate change, ozone depletion, mineral, fossil and renewable resource depletion and water resource depletion. The plant is divided into 3 lines according to the effluent treated: a) In the first line, wastewater is treated by the electrooxidation (EO) and electrocoagulation (ECo) process while producing hydrogen and recovering energy. The results showed that the avoided impacts of the hydrogen unit are quite similar to the environmental impact of the hydrogen unit itself. Therefore, in all categories, EO and ECo have high environmental impacts. The main impact generated in EO has been mainly due to the electricity consumption required to run up the process in the operation stage. b) In line 2, wastewater is treated by Multistage Humidification-Dehumidification (MHD) technology and electrowinning technology to recover nickel and water for reuse. The results showed that in categories such as mineral, fossil and renewable resource depletion, acidification or freshwater eutrophication, the environmental benefits of recovering nickel have been higher than the environmental impact due mainly to avoiding nickel extraction. However, the environmental impacts of these units in categories such as water resource depletion, climate change and ozone depletion are much higher than the avoided impacts due mainly to the electricity consumption required at the operation stage of the MHD unit. c) Line 3 treats the wastewater and recovers oil and grease. The results show a low environmental impact in the categories analysed due to low energy consumption and the few chemicals used. The final report indicates that the system needs to be optimised in terms of energy consumption (Ecowama, 2016).
<u>RQ 3</u>: The results at Level I technology show **modest performance**. MHD technology has started, modestly, to be scaled up commercially by some business partners from the project consortium (Ecowama, 2016), but there is no record of results of Level II collateral effects.
Level III (Nexus) implications of the innovations
<u>RQ 4</u>: No consideration of Level III problems.
<u>RQ 5</u>: (1) The recovery of nickel and clean water for reuse (tertiary flows) from heavily contaminated wastewater flows is highly demanding of electrical energy, and the hydrogen power produced in the process does not compensate such energy requirements. The use of extensive clean solar energy might be invoked but that would go back to the issue (already indicated in Innovation 1) about the materials required to produce such energy carriers. Thus, to keep nickel production profitable in the long term, the pace and size of the primary flows (energy and materials) required by the recovery plant will probably place pressure on primary flows (e.g., materials stocks) made available by the biosphere. (2) All the points developed in Innovation 1 about the mass production itself of high order recovery plants can be applied in this case.

Table 16. Critical assessment of the FP7 project R3Water (Innovation 12)

Goals and imaginaries:
To develop a set of technologies to optimise wastewater treatment plants (e.g., minimising operational costs such as electricity consumption) into more efficient facilities that recover clean water for reuse, nutrients and other possibly valuable materials and energy sources. The project expects to reduce environmental impacts (e.g., GHG emissions) when running wastewater treatment plants and relieve pressure on resources such as water, as well as to recover several outputs of economic interest for the market and the industrial sectors.
Level I technology: Set of technologies to optimise wastewater treatment plants into more efficient facilities that recover clean water for reuse, nutrients and other valuable materials and energy sources.
Level II descriptions and problems:
RQ 2: The project developed 12 technologies within three topics: "Reuse of water", "Resource recovery" and "Resource efficiency". For the first, the project developed technologies such as an online monitoring technology faster than traditional sampling plus a laboratory method to detect E. coli bacteria or a real-time online monitoring system for pathogens and organic pollutants in treated water. For the second, the project investigated, for instance, a hydrothermal carbonisation technology to recover phosphorus as fuel for the cement industry from carbonised sludge, as well as to produce activated carbon. For the third, the project tried to improve, for instance, the removal of nitrogen from the water rejected from the anaerobic digestion of sludge (R3water, 2017) (CORDIS, 2017b). The technological solutions were tested at different demo sites. Several solutions showed enhanced performance in terms of energy consumption and increased resource efficiency. However, further improvement is called for a) the nitrogen removal process because demonstration was prone to failure, b) the routes to treat sludge ash because the proposed solutions need significant processing, c) aerobic biological wastewater treatment through microbubble technology due to modest testing results and d) the software technology "Model Predictive Control". The project suggested recommendations for topics. For "Reuse of water": harmonisation of quality criteria for water reuse (e.g., common standard within the EU) and online water monitoring technologies within the EU water directives. For "Resource recovery": harmonisation of legislation and directives for recovered materials and products and promotion between member states and public authorities. For "Resource efficiency": application of incentives to establish sustainability benchmarks to balance medium and long-term sustainability with short-term economic cost disadvantages (CORDIS, 2017b). Policy recommendations to overcome obstacles on a large commercial scale were also indicated: a) incentives to overcome reluctance to invest caused by short-time operating contracts, b) simplification of the permissions for demonstrations at industrial sites and c) careful use of wording and terminology in official documents to create positive attitudes toward the technological solutions (sic!) (CORDIS, 2017b: 6).
RQ 3: The results at Level I technology show **modest performance**. By the end of the project some of the technologies developed were almost ready-to-market, but there is no larger scale implementation.

Level III (Nexus) implications of the innovations
RQ 4: No consideration of Level III problems.
RQ 5: (1) The large-scale implementation of the technologies will require significant processing and a high requirement of energy consumption despite efforts to minimise this cost. The widespread use of clean solar energy might also be invoked in this case, but that would go back to the issue (already pointed out in Innovation 1) of the materials needed to produce these energy carriers. (2) All the points developed in Innovation 1 about the mass production of these high order technologies can also be applied in this case.

Table 17. Critical assessment of the H2020 project DiscardLess (Innovation 13)

Goals and imaginaries:
To develop knowledge, a set of tools, databases and recommendations for the gradual elimination of discards in European fisheries in line with landing obligation (LO) implementation (in full force since 2019). Discarding is the practice of returning unwanted catches to the sea, either dead or alive, because fish is below the minimum landing size, because of the existence of quota limits or because the commercial value is low (Discardless, 2016a). The project aims to support adaptation in fisheries practices by first avoiding unwanted catches; second, reducing the mortality of unavoidable unwanted catches; and third, making optimal use of unavoidable unwanted catches once they have been landed. Overall, the project expects to make the fishery more sustainable by relieving pressure on fish stocks and by transforming sea residues into valuable resources.
Level I technology: Analytical and mapping tools, online database and policy recommendations to gradually eliminate discards in European fisheries
Level II descriptions and problems:

RQ 2: The project selected several case studies in different European regions to support adaptation in fisheries practices and developed a) a database for a global view of landings, discards and catches by different categories (e.g., vessel length, gears, species); b) a manual to improve the gear to avoid unwanted catches; c) interviews with fishers to better know their point of view on discarded fish (e.g., tactical methods to avoid unwanted catches); d) suggestions (supported by a benefits–costs analysis) for onboard handling and processing solutions to better control unavoidable unwanted catches; e) mapping tool to better guide fishers' decisions on where and when to fish, to avoid unwanted catches and maximise benefits; f) valorisation options about the most suitable uses of unavoidable unwanted catches once landed (e.g., vitamins, biogas or insect meal) (Discardless, 2019b). Several barriers (and recommendations) are considered through experiences in the different regions (Fitzpatrick and Nielsen, 2019). In the North Sea and North Western Waters: few changes observed in fishing practices to avoid unwanted catches, and reports on discards rates and landing of unwanted catches are very few. Electronic monitoring is one of the suggested measures. In the Azores: most of the fishers interviewed were not aware of the LO regulation, stating that it made no sense in this area (Fitzpatrick and Nielsen, 2019: 14) because they use one of the most selective fishing techniques in Europe. Also, the potential use of unavoidable unwanted catches once landed appears limited due to infrastructure and high processing costs. Continued monitoring through onboard observer programmes, scientific surveys and further testing fishing experiments to avoid unwanted catch are suggested. In Mediterranean areas there is a higher reluctance to LO and actors such as the Mediterranean Advisory Council consider that the landing of undersized fish is not operationally and economically feasible and the register of eligible discards will increase bureaucracy and onboard work. A change in mentality is suggested, although it is considered the most difficult part (Fitzpatrick and Nielsen, 2019: 18). In the Baltic area: discarding rates of unwanted catches have not decreased and gear selectivity has not improved, so proper monitoring is highly suggested. Additional general barriers (and recommendations) include a) fears in the industry about a negative impact by reporting discard data. Hence, the quality of discard data is not improving. The use of remote electronic monitoring and cameras across all fleets is suggested but will require some degree of industry acceptance. b) General negative attitude toward the LO among fishers due to concerns about fishing profitability (e.g., more crew would be required) and the feasibility of the valorisation process. Regional frameworks and plans, and economic incentives to use unwanted fish in "valorisation options" are called for, although they are expected to happen only in the very long term (Stokstad, 2019).
RQ 3: The results at Level I technology (e.g., database, mapping tool and manual) show relatively modest performance, but when these innovations are implemented in the regions, several problems emerge (the so-called "barriers" described above). In terms of a record of results of Level II collateral effects, some members states, for instance, have reported increased refusals to take observers onboard in 2017 (Fitzpatrick and Nielsen, 2019: 19).
Level III (Nexus) implications of the innovations
RQ 4: No consideration of Level III problems.

<u>RQ 5</u>: (1) The valorisation process of unavoidable unwanted fish ("sea residues") on a large scale will imply direct costs such as infrastructure, technical facilities, energy, water and labour (which might also represent an opportunity cost for other activities). (2) In the biophysical sense, the size and pace of primary sources required to make this valorisation activity economically profitable will probably put pressure on the primary sources made available by the biosphere in the long term. In the case of suggesting energy be produced with extensive clean solar energy, that would go back to the issue of the materials needed to produce these energy carriers (issue already pointed out in Innovation 1).

Table 18. Critical assessment of the H2020 project REFRESH (Innovation 14)

Goals and imaginaries:
To develop an approach and tools to prevent avoidable food waste, maximise the value of unavoidable food waste and optimise the utilisation of resources within the food system (including packaging materials). Overall, the project expects to contribute to the circular economy by a) reducing food waste, b) reducing GHG emissions from transporting and managing food waste, and c) generating economic benefits by making marketable food products from unavoidable food waste.
Level I technology: Protocol, guidance, database, analytical IT tools to reduce food waste.
Level II descriptions and problems:
<u>RQ 2</u>: The project: a) implemented a survey in 4 piloting countries (Spain, Hungary, Germany and Netherlands) to study household practices on discarded food and developed strategies to change consumer behaviour and reduce food waste, b) developed a food waste compositional database associated with valorised products and researched new economically feasible options such as food fibre production from a chicory residue, c) investigated options to produce marketable food products such as animal feed for pigs and chickens from reprocessing waste food that includes meat, e) developed an analytical tool to assess GHG emissions and costs for valorisation options (Ecologic Institute, 2019a, 2019b) (CORDIS, 2017b) and f) tested voluntary agreement approaches (the so-called "framework for action", FA) in the pilot countries to establish evidence for a pan-European FA that could be applied in other European countries. The tests showed significant variations across pilot countries in terms of socio-economic factors and different food waste starting points. Such variations made it difficult to design and implement a single pan-European agreement. Thus, evaluation in this part of the project changed toward the impact and success of each FA pilot (Boulding and Devine, 2019:60). As for the impact of the FA pilots, in all of them it was very difficult to obtain food waste measurement from organisations and businesses due to commercial sensitivity, economic costs, previous negative media experiences, and refusal to commit to public reporting for a measurement methodology. These so-called "barriers" did not allow the evaluation, in quantitative metrics, of whether FA pilots had driven a reduction in food waste. Instead, the impact focused on several short-to-medium term success indicators (Boulding and Devine, 2019:56). For future evaluation of FA performance, gathering data on food waste is important.

<u>RQ 3</u>: The results at Level I technology show modest performance, since the FA pilots originally proposed did not establish evidence for a pan-European FA, and the performance of the FA in the pilot countries could not be evaluated. There is no larger scale implementation of the innovations proposed, so there are no records of results of Level II collateral effects.
Level III (Nexus) implications of the innovations
<u>RQ 4</u>: No consideration of Level III problems.
<u>RQ 5</u>: (1) The economic valorisation of unavoidable food waste products (secondary flows) on a large scale would involve direct costs such as infrastructure, technical facilities, energy, water and labour (which might also represent an opportunity cost). Similar to the previous Innovation 13, the size and pace of primary sources required to make this valorisation activity economically profitable would probably put pressure on the primary sources made available by the biosphere in the long term. In the case of suggesting energy production with extensive clean solar energy, that would go back to the issue already pointed out in Innovation 1.

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Chapter 4. [13]

Case study: Don't they understand climate science? Reflections in times of crisis in science and politics

Abstract

During the 2016 US presidential election, discussions on the social website "I fucking love science" (IFLS) mainly invoked a polarized version of the modern model of legitimation entangled with the deficit model by claiming that "climate change is a matter of science, truth and facts but 'they', the deniers, do not understand the science". This chapter challenges this narrative to open a dialogue space and identify criteria for dealing with the climate issue under conditions of high uncertainty and complexity. Analysis reveals how the dialogue might experience a stalemate when criticisms against this narrative are based on the need to show an inflicted harm for which this narrative can be blamed. Simultaneously, the same condition of uncertainty disarms a core principle from the modern model by which legitimate action is to be based on predicting catastrophe in climate change. At stake is an essential part of the present: our praxis.

Key words: uncertainty, complexity, legitimacy, climate change, public deficit model, praxis

1. Introduction

The beginning of the twenty-first century is characterized by a growing awareness of systemic crisis (Benessia and Funtowicz, 2016). Many authors refer to a crisis of trust toward our scientific and political institutions. For instance, Armingeon and Guthmann (2014), Pausch, 2014) and Dotti Sani and Magistro (2016) describe the 2008 financial crisis as a turning point after which trust in political institutions, financial elites and experts has been increasingly eroded all over Europe, to some extent climaxing with the outcome of the Brexit referendum in 2016 and political anti-establishment movements (Callinicos, 2017; Pirro and Van Kessel, 2018). In North America, the sense of a generalized crisis of public trust in established political parties and in scientific advice, especially on climate change, is seen to have crystallized with the election of Donald Trump as President of the United States (Pew Research Center, 2017) (Gauchat, 2012) (National Academies of Sciences, Engineering, and Medicine, 2017).

[13] This chapter contains the version accepted on 24 March 2021 prior to the final version published and cited as follows: García Casañas C. Don't they understand climate science? Reflections in times of crisis in science and politics. Public Understanding of Science, 30(8):947-961. Copyright © 2021 (SAGE Publications Ltd). doi:10.1177/09636625211011882

Funtowicz and Strand (2007) argue how institutions of governance and science in modern societies were shaped and coevolved under a dual legitimacy system, also called the modern model of legitimation, whose central belief is that science produces valid, reliable, value-neutral and objective knowledge to inform politics. In other words, Western institutions coevolved under what most post-empiricist philosophy of science and science and technology studies (see, for example, Latour, 2007) would see as the *illusion* of demarcation between facts (realm of science) and values (realm of politics). The point of departure of this chapter is that systemic crisis can be understood as the sign of a deeper crisis of the dual legitimacy system. Such a crisis may be manifesting itself in the two realms that have traditionally been conceived as separate entities: science (Funtowicz et al., 2016) (Funtowicz and Saltelli, 2017) (Kovacic, 2013) (Sarewitz, 2017) and politics as symptomatically expressed in the outcome of the election of Trump as US President in 2016. Funtowicz and Ravetz (1993) have suggested that facts and values are, indeed, not independent from each other and there is a need to develop institutions that are able to cope with hybrid, or extended facts–values under conditions of high uncertainty and high stakes when dealing with social and environmental problems in these times.

Still, Northern and Western governments when, for example, confronted with apparent public opposition to scientific advice may seem not to perceive the depth of the crisis. On the contrary, scientific advice has never been more prominent in policy making, imagined as a source of technological innovation, economic growth and progress as well as value-neutral knowledge, or "evidence" as it is often called (American Association for the Advancement of Science, 2017; OECD, 2015; UNESCO, 2016). Some responses have taken the form of the so-called "post-truth" debates in academic (Boler and Davis, 2018; Lewandowsky et al., 2017) and political spheres.[14]Other reactions have taken place in the public arena such as the March for Science,[15] which introduced slogans like *Science Speaking Truth to Power* after Trump's election. In this chapter we critically analyse the main reactions within the social network "I fucking love science" [16](henceforth, IFLS) following Trump's election in relation to the urgent concern of climate change. A central narrative claimed within IFLS was that "climate change is a matter of science which is about facts and truth, but they ignore and do not understand climate science so they should be (re) educated in science". This reaction appears to increase polarization and reinstate a version of the modern model entangled with the public deficit model. How might "we", as a community, promote a space of public dialogue, democracy and conviviality? Specifically, in this chapter we aim to identify criteria to deal with the complex climate issue under conditions of high uncertainty and high stakes (Funtowicz and Ravetz, 2000, 1993).

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[14]See for example the 2017 European Commission conference, EU for facts. Evidence for policy in a post-fact world (https://ec.europa.eu/jrc/en/eu4facts) (accessed 13 September 2019)
[15]Available at: https://www.marchforscience.com(accessed15 September 2019)
[16]Available at: https://www.facebook.com/IFLScience/ (accessed 13 September 2019)

This chapter is structured in four sections. In the first, we introduce the methodology applied to conceptualize the main science-based narratives claimed on the social website being studied and present three narratives. In the second, we compare and discuss these narratives in the light of the repertoires from the modern model, the public deficit model and narratives of scientific progress. In the following section, we challenge the most predominant narrative identified in IFLS which appears to increases polarization through a version from the modern model interlinked with a repertoire from the public deficit model. Specifically, we aim to open a dialogue space and identify criteria for dealing with the climate issue under conditions of complexity and high uncertainty. For this purpose, in the first subsection we revisit previous criticisms of the deficit public model in the light of Latour's insights (2007, 2018) to investigate whether (and how) a public dialogue on climate change might experience a stalemate when those types of criticisms are raised against those who sustain the main narrative identified in IFLS. In the second subsection, we analyse how scientific uncertainty is handled in a political statement about climate change from the Trump administration (outside IFLS) to see whether the modern model might also be, paradoxically, implicit in Trump's policy. We then explore how this condition of uncertainty disarms a core principle from this model embedded in the main reaction to Trump's policy identified inside IFLS. In the last section, we will end with some concluding remarks.

2. Methodological approach

The IFLS Facebook page was created by Elise Andrew in 2012 and rapidly gained in popularity, attracting around 24.5 million followers by 2020.[17] IFLS, described as the "funny side of science", is an online platform in which participants engage with the information posted by the administrators in the form of jokes, quotes or curiosities, but also, less humorously, with the roles that science is imagined to have in society around topics like climate change following Trump's election. The methodology applied is based on grounded theory (Creswell, 2014), since it is a suitable qualitative approach to derive and systematize abstract patterns of an interaction grounded in the views of participants within a social network. This research approach has involved several interactive tasks: data collection, analysis, generation of the main science-based narratives and their positioning within relevant literature.

The type of data collected is characterized by the interaction between the audiovisual material and/or textual information posted by the administrators (called "entry" in our analysis) and the respective replies expressed mainly in comments and threads. There may typically be up to four such entries per day and the number of comments can reach 20,000 per entry, with exceptional cases that receive more comments. A qualitative analysis of IFLS required a limited *text corpus*.

[17]Available at: https://www.facebook.com/pg/IFLScience/about/?ref=page_internal(accessed 14 September 2019)

The text corpus covers a three-month period from 8 November 2016 (Trump elected as US president) and was composed according to the following systematic collection criteria. Firstly, entries were selected by checking the information posted and the initial replies (filtered by the "most relevant" category) against three key interlinking topics: climate change, Trump's election and the imagined role of science in these topics. Entries relating to the commercialization of products, games, riddles and curiosities about techno-scientific advances with no substantial relation to the topics were disregarded. Secondly, samples of replies were collected according to two distinct types of interactions: a) those with a clear, explicit reference to the key topics were considered of "high importance" (17 entries with samples of 400–500 comments per entry) and b) interactions with a weaker relation to the key topics but of possible interest were labelled of "medium importance" (14 entries with samples of 100–200 comments each).

The text corpus was analysed by manually codifying the samples selected in each entry according to different categories of interaction. These categories were interrelated and regrouped to form broader categories until predominant patterns of interaction could be conceptualized. These patterns were mainly characterized by a positive interaction, resulting in support and further participant exploration of the information posted. For instance, an entry mentions a traditional cult of ignorance in the US, which is embraced positively by participants whose replies follow arguments such as "people are so wilfully ignorant" or "they don't want to be educated". For more detail about this methodological step, please see this instance in Appendix 3 at the end of this chapter, where Figure 1 represents the entry posted on 11 November 2016 and Table 19 shows the codifications assigned to different categories of interaction and the interrelation of these categories. Patterns of interaction that are far less predominant are characterized by criticisms and disagreements with the entry and other less usual types of argument. At the same time, we have regrouped predominant patterns with similarities in content and features across different entries into broader patterns to conceptualize the main science-based narratives. The analysis of the text corpus was also subject to the saturation criterion, a key concept from grounded theory by which the codification and narrative generation process ended when the patterns were saturated, that is, when data no longer sparked new insights (Charmaz, 2006). The dataset analysed covered 17 entries (13 of "high importance" and 4 of "medium importance") and a total of 5,324 comments, whose average length is 24 words. We reviewed the codification and the narrative conceptualization three times to strengthen consistency.

What follows are the three main interlinked narratives on the imagined role of science in society resulting from text analysis. The narratives are understood as a set of entangled beliefs, ideals and imaginaries, and are held and narrated by certain actors, "we", who refer to other actors as "they". They also appear according to greater predominance within IFLS, and the titles assigned are my suggestions based on the attempt to synthesize the content of these narratives.

Narrative 1: They do not understand climate science nor do they wish to understand it

Climate change is a matter of science which has provided "us" with overwhelming evidence about the human impact on climate change. Science is about truth and facts. It is not about personal and religious beliefs or opinions. It is neutral and has no political bias or parties. The problem is not only that "they" (Trump, the elected politicians and the people who voted for them) are ignorant, uneducated and do not understand climate science, but also that "they" do not wish to understand climate science and choose to continue being ignorant. They" are denying science and are anti-science. "They" should be re-educated in science and "we" should show "them" the importance of science.

Narrative 2: Science as an issue of safety and hope in the era of Trump's policy

Trump's election as president threatens to destabilize the world order. "They" (Trump, the elected politicians and the people who voted for them) are a threat to our planet, the environment and science itself because science depends on government funding. But "we" won't be lost as long as there is science. "We" love what science does for "us"; it brings "us" together.

Narrative 3: Science as moral progress to control population growth and relieve environmental problems

Population growth is a problem because it aggravates environmental problems such as the pressure on natural resources and climate change. Population growth should be corrected, mainly by different types of birth control measures, which should be the responsibility of individuals and government. Science and education have provided "us" with this responsibility, so "we" need more education. Third world countries, in particular, should introduce more education and birth control since they are less educated than "us". Controlling birth also makes "us" happier because "we" have more free time and fewer expenses. Ultimately, technological innovation such as GMOs may also relieve the problem.

3. Main science-based narratives in historical perspective.

3.1 Narrative 1. They do not understand climate science nor do they wish to understand it

Within this multifaceted and most predominant narrative identified in IFLS, at least two main interlinked repertoires can be distinguished that resemble the core beliefs of the modern model and the public deficit model, respectively. In what follows we highlight these repertoires and we discuss them in the light of these models.

On the one hand, a repertoire about how science is conceived and imagined in the climate change issue can be distinguished: "*Climate change is a matter of science which has provided "us" with overwhelming evidence about the human impact on climate change. Science is about truth and facts. It is not about personal and religious beliefs or opinions. It is neutral and has no political bias or parties*". This repertoire echoes an old repertoire of demarcation from the modern model of legitimation. The modern model or dual legitimacy system is characterized by a set of ideals on the progress of societies and the central belief that science deals with "facts" and produces valid, reliable, value-neutral and objective knowledge to inform politics on what to do (Funtowicz and Strand, 2007).A full discussion of the historical origins and features of the modern model is outside the scope of this chapter and we will only introduce briefly some historical and cultural events that gave rise to those beliefs. Although scientific revolution as such is a post hoc historical construct (Shapin, 1998), the thinking of figures such as Bacon, Descartes, Galileo and Leibniz contains the seeds for the emergence of the central tenets of the dual legitimacy system (Rommetveit et al., 2013). At a time when the cosmological vision of the earth spinning quickly around the sun was not obvious from observation itself and the senses could be deceptive, Galileo and later Descartes, in a more radical way, distinguished between primary and secondary qualities (Husserl, 1954). Primary qualities were related, for example, to the position, weight or speed of a feather, and therefore susceptible to exact measurement. Secondary qualities, on the other hand, included colour, sound and sense impressions such as that of a feather touching one's nose. This was a very significant conceptual distinction: the human being (qua scientist) separated from the outside world, also referred to as the universe or nature, which is suspended in an abstract sphere based on the language of geometry and mathematics (Rommetveit et al., 2013:22). Suspending the world in this abstract and ideal space seemed a better option in the face of deceptive corporal senses and the devastating religious war between Catholics and Protestants in Europe (1618–1648). In this way, central beliefs began to interlock as a result of the Peace of Westphalia of 1648.The role of the modern state emerged as the provider of social order and stability through clear and certain ideas, which would be useful for religious and political negotiations. These clear ideas were to be isolated from unqualified opinions and would be conceived as "value-neutral and objective" and as describing the "truth" or the almost "truth" of the outside world. These ideas would tell power what to do.

Scholars like Shapin and Schaffer (2011) have also argued how scientific knowledge had to be brought to society. In the constitution of the Royal Society of London and other scientific societies throughout Europe, it was explicitly forbidden to talk about politics, religion, metaphysics, passions or moral values. Disagreement and dissent were possible but, to quote Shapin (1998:135), "without bringing down the whole house of knowledge". The human scientific enterprise of *new* knowledge had to be made attractive for the social order, clearly outlining the boundaries between what was and was not scientific. In this way, our societies and institutions of governance and science coevolved under the illusory demarcation between "facts" (realm of science) and values (realm of politics) (Latour, 2007).

In a similar direction, Jasanoff (2005, 2012) introduced the concept of "civic epistemologies" by referring to the culturally specific ways in which publics expect scientific knowledge to be produced and consequently to be used in decision-making, and argues how such epistemologies are inserted in the institutional and scientific practices, discourses and techniques that historically have been exercised. At the same time, the efforts to legitimate such discourses and forms of reasoning have depended on acceptance by citizens. From this perspective, the repertoire being discussed can be seen, more specifically, as contemporary cultural expectations by an online community about the idealized role of science from the modern model in the climate change issue, and such expectations and beliefs have been fuelled by discourses (and practices) like those coming from an outstanding international scientific body: the Intergovernmental Panel on Climate Change (IPCC, 2019). The IPCC has warned and provided "evidence" about the threat of climate change through catastrophic predictions since the late eighties and has claimed that its scientific reports are guaranteed by objectivity and neutrality (IPCC, 2019). Below, there are several comments (respecting participant anonymity) that express the repertoire of demarcation from the modern model and a clear instance (the first) that invokes the IPCC's authority:

- *If you don't believe me, I encourage you to read this. This report*[18] *was compiled by scientists from all around the world using thousands of research studies. It is not biased toward any political agenda* [...].
- *Why do you blind yourselves from scientific evidence? Science has no political bias.*
- *Climate change is a scientific fact; it does not care about anyone's opinion [...].*
- *Science is not left-wing or right-wing. The science says that humans are contributing to climate change [...]. What makes it political is that politicians control the government's ability to affect the necessary changes...*
- *Science is neutral [...].*
- *Ignoring the facts and truth in front of you and instead sticking to your ideals [...].*

[18] There is a link posted to the Fifth Assessment Report from the IPCC.

A core principle from the modern model would, then, imply that legitimate action should be based on having "value-neutral and objective" knowledge about predicting catastrophe in climate change by the experts. We shall discuss this principle in greater depth in the next section where this principle will be disarmed and an essential part of our political life for dealing with the climate change issue will be disclosed. For now, we will provide additional characteristics of this repertoire of demarcation. This repertoire has also been referred to as the "received view of science" (Rommetveit et al., 2013:11), roughly defined as a mixture of cultural beliefs, norms of practice and ideals to navigate by. Since ideals such as objectivity and neutrality cannot be tested by experiment or empirical observation according to the very criteria of scientific practice, the received view is composed by a set of *unscientific beliefs* in science. In other words, it is, indeed, an *ideology*. From a different perspective, Latour (2007) distinguishes two types of tasks that modern societies combine: the work of purification as the intellectual and ideological work that aims to separate "Nature" from "Society", "Science" from "Politics", "facts" from "values"; and the work of hybridization that increasingly entangles the natural world with society and culture. Latour argues how these combined tasks become functional to evade the political responsibility of scientific activity itself.

Moreover, within the main narrative identified in IFLS can be distinguished another repertoire: "*The problem is not only that "they" (Trump, the elected politicians and the people who voted for them) are ignorant, uneducated and do not understand climate science, but also that "they" do not wish to understand climate science and choose to continue being ignorant. "They" are denying science and are anti-science. "They" should be re-educated in science and "we" should show "them" the importance of science"*. This repertoire echoes the features of the public deficit model. The public deficit model reappeared in the mid-1980s to combat the increasing mistrust, discontent and scepticism of science in previous decades (Nieto, 2016) (Irwin and Wynne, 1996). Specifically, the deficit model became popular in the field of social research known as public understanding of science and through its parallel appearance in the influential 1985 report of the Royal Society of London (Bauer, 2009). The model embedded in this report announced a deficit in support for science that was attributed to a deficit in knowledge of scientific "facts". In particular, the report was especially concerned with those "disinterested attitudes" (Bauer, 2009: 4) toward science and assumed that better knowledge drives positive attitudes – "the more you know, the more you love it". In this way, the public was seen as ignorant, not well-informed and with a deficit in knowledge of science. Increasing scientific literacy and re-educating in science (and technology) would therefore improve the support for and understanding of science. A return to the repertoire discussed reveals that the subject "they" (represented by Trump, the elected politicians and the citizens who voted for them) resembles the subject "the public" of the deficit model. The following exemplify the characterization of the subject "they" and those disinterested attitudes:

- *They don't want to be educated and they don't listen to us.*
- *Somehow uneducated masses believe they have the right to deny science.*
- *What an awful leader ☹— Hello Donald Trump, goodbye Earth. Anyone who supports his decision is without question, a monster & threat to the planet. Shame on them! Wake up and #think people*.
- *It´s just a shame we have to share this planet with such a large amount of ignorant and uneducated Americans.*
- *The problem is not science, it's the people who do nothing to learn about it. If scientists ran the governments the world would be a better place but sadly the governments are in the hands of ignorant politicians.*
- *In the face of overwhelming evidence, you choose to be wilfully ignorant.*

In addition, those disinterested attitudes to (climate) science that seem to be alleviated with more knowledge of scientific "facts" are exemplified by the following comments:

- *This is why a renaissance education with a solid science base, tempered by critical thinking skills is key to the future.*
- *I fucking love science please keep educating the ignorant about the critical state of the Earth's rising temperature.*

The deficit model has also been justified by reasons of democracy since an "ignorant public" was seen as unfit for democratic electoral participation and a well-informed public was conceived as making better political decisions (Bauer et al., 2007). The following comments in IFLS resemble these features:

- *Sadly, these people get to vote as if their total lack of understanding counts the same as other people's informed opinion.*

To sum up, the most predominant narrative identified in IFLS upon Trump's election reinstates a version from the modern model that is entangled with a repertoire that resembles the public deficit model, and this narrative appears to increase polarization. How might criteria be uncovered to deal with the climate change issue and to promote a space of public dialogue and conviviality? We will pursue this question in the following section. Beforehand we will briefly discuss the other two narratives identified in IFLS.

3.2 Narrative 2: Science as an issue of safety and hope in the era of Trump's policy

The second predominant narrative identified in IFLS is closely interlinked with the most predominant. If "they" (Trump, the elected politicians and the people who voted for them) are denying the scientific "facts" and "evidence" on climate change (as expressed in the first narrative), "they" are a threat to the environment and science itself. In this situation, science is conceived as an issue of hope and unity upon Trump's election. The following quotes express this last narrative:

- *We won't be lost as long as there is science.*
- *This is why I love science because at the end of the day all of this is insignificant.*

For some participants science was an even more explicit issue of *faith*, exemplified by the following quotes:

- *I always have more faith in science than in people.*
- *But in the end, truth, fact, science and true faith (not blind) will move us forward again to the light.*
- *They don't believe in climate change, they don't believe in science.*

Such statements were, sometimes, clarified by other participants who stated that science is not about personal or religious beliefs. Interestingly and more dogmatically, for other participants any post referring to the new US president was perceived as annoying and the IFLS website itself was repeatedly critiqued by comments such as:

- *IFLS, it is not scientific, please keep out of politics!*
- *Go to your safe place, IFLS.*
- *Opinions hold no place in science.*

These comments disclose how the modern model has worked at a deeper cultural level, to the extent that, for some, science has become something to which one belongs and is *judged* as being safe to belong to.

3.3 Narrative 3: Science as moral progress to control population growth and relieve environmental problems

Although the third narrative is not as predominant as the other two, it still displays additional signals of how modern narratives of scientific progress have worked at a deep cultural level. In this narrative, population growth is mainly embraced as a situation of conflict that aggravates environmental problems such as climate change, and science and education are petitioned as providers of the appropriate moral attitude to address the problem, and ultimately, to increase happiness. This narrative shares certain features of the Marquis de Condorcet's historical utopian view of scientific progress in the late eighteenth century (Strand, 2013). According to Strand (2013), Condorcet shared the same pessimistic view as Malthus: the decline of happiness and descent into barbarism, since the growing human population will outstrip food supply on a planet with finite resources. However, his response to this problem was different: science and education will propagate reason and rational thinking, which will improve human morality. Consequently, sophisticated citizens will know how to create sustainable societies because they will value happiness and will stop population growth. From a different perspective, Foucault (2008) introduces the concept of biopolitics by arguing how more subtle conduct was induced in the population through modern state administration from the mid-eighteenth century onwards in issues such as *birth-rates.* According to Foucault (2008), a type of economic thought (that of liberalism) introduces the idea that the naturalness of the market reveals something akin to truth; hence the task of new economic experts is to inform the government of the "truth" of the market's natural mechanisms (Foucault 2008, 17). In other words, liberal thought forms an apparatus of knowledge–power which justifies the belief that knowledge provides government with the power to act in terms of what is true or false or what is or is not right to do; and this conduct was established among the population. Transferring this perspective to the topic of the third narrative gives rise to the following corrective standard: if science and experts are tasked with disclosing the solution to the problem of population growth, governments and citizens should act according to the "truth" dictates of science. The following quotes taken from IFLS reflect this corrective moral standard:

- *Hasn't science shown that the more educated a population is, the less kids they have? Everyone needs access to education. Quick!*
- *We should stop breeding, because if not, we are making the same mistake.*

4. Toward a space of public dialogue and conviviality

In the previous section, we argued how the main narrative identified in IFLS is anchored to an old repertoire from the modern model entangled with the public deficit model and that this narrative appears to increase polarization. In this section, we challenge this narrative, aiming to open a dialogue space and identify criteria for dealing with the climate issue. For this purpose, we begin by reviewing existing criticism of the deficit model that could be raised against this narrative to investigate whether (and how) a public dialogue might experience a stalemate.

4.1 Revisiting criticisms of the deficit model

Criticisms of the deficit model generally advocate a transition from its top-down perspective to the bottom-up model in which more participation in scientific knowledge production can lead to more democratic processes (Irwin and Wynne, 1996; Ziman, 1991; Stilgoe et al., 2014). However, such a transition appears not to have been reached or effectively undertaken (Hagendijk, 2004; Wynne, 2006; Macnaghten et al., 2005). Other criticisms have argued that the information needed by citizens to make better decisions is not about the content of science, but the political role of science and technology (Collins and Pinch, 1998).

In what follows, we revisit Irwin and Wynne's (1996) criticism of the public deficit model by following Latour's insights to learn a lesson from taking this critical stance against the main narrative conceptualized in IFLS.

Interestingly, Latour (2007) has pointed to an ironic aspect of the "modern constitution": how a critical stance might reinforce what the critique is trying to defeat. Latour argues that the critique aims to find prodigious causes such as an absolute domination and invasion by science and technology. Paradoxically, the critique would involve assuming that we are being invaded by a scientific and technical world separated from society. However, the only causes recognized by the modern constitution (Science/Nature separated from Politics/Society/Culture) are indeed miraculous. In this way, the critique allows blame to be placed on science, as well as the victimization of others. In addition, Latour (2018) has pointed out a problem of dimension and scale which we must face up, namely, a basic dichotomic tension between the global and the local. This tension implies that simultaneously:(1) the planet is too big to remain within the limits of a given locality and (2) the planet is too limited and narrow for the "global" and the world of globalization and thus there is need for locality (Latour, 2018:16). In the following two paragraphs, we review Irwin and Wynne's (1996) criticism of the public deficit model by keeping in mind this dichotomic tension (between the global and the local) and the action of blaming science.

Irwin and Wynne critically analysed the vision of science (and technology) portrayed in the deficit model of the Royal Society Report through three cases of environmental problems: the pollution of hill sheep-farming in the Lake District (United Kingdom) by the 1986 Chernobyl disaster and two polluted sites located near hazardous industries in northwest England. The critique repeatedly shows how, in dealing with environmental problems, science and scientific knowledge was one-dimensional, reductionist, abstract, standardized and practically devastating to the environment and humans (e.g. the cultural and social identity of farmers was under threat because people experience scientific knowledge as a social negotiation; however, local knowledge tends to be excluded). The critique also shows how the consequences would have been different if the local, complex and multiple dimensions of humans and nature had been considered and included in a timely fashion in a participatory process of scientific knowledge production.

On the one hand, this critical stance involves an awareness of the condition of complexity of environmental problems. However, science and every solution deriving from it (e.g. techno-scientific solutions) appear as imperfect in the face of this complexity of the problems, as if the solutions were to be judged according to some cognitive or corrective standard. More specifically, criticism of science appears to be based on harm and injustice to nature, the environment or human beings (e.g. farmers or lay people). In this way, science (and the technological solutions deriving from it) can be *blamed.* This insight might show why discussions about environmental governance are so difficult and the possibilities of arriving at a consensus are small. On one side, there might be optimistic voices advocating for the vision of science portrayed in the deficit model and proposing techno-scientific "solutions". On the other, there will be voices repeatedly trying to show how methods and solutions (deriving from science) for dealing with complex problems caused injustice and harm. Discussions about genetically modified plants present a similar stalemate of cognitive incommensurability (Strand, 2001). In addition, Irwin and Wynne's criticism of science also appears to be based on harm inflicted at the "local" level, which is where environmental problems are lived and experienced. Blame can therefore be placed on "global" technological solutions deriving from science.

A public discussion on climate change might experience a similar stalemate. For instance, some voices might advocate (naively or desperately in the face of an incipient awareness of the complexity of the climate change issue) the main beliefs and ideals about climate science identified in IFLS and described as Narrative 1 (i.e. that science is about truth and facts [...] they [...] are ignorant, uneducated [...] they should be re-educated in science).[19] Other voices might criticize this narrative anchored to the modern model entangled with the public deficit model. Such criticism might include cognitive issues about the need to demonstrate the inflicted harm for which this narrative can be blamed. Specifically, they might criticize climate science and its particular "global" technological solutions to combat the complex problem of climate change (e.g. technology to capture CO_2) by assessing them and persistently showing their ineffectiveness and aggravation of other environmental problems on a "local" level (e.g. increasing depletion of non-renewable resources to produce those technologies on a large scale). Conversely, the voices that hold the main beliefs described as Narrative 1 might point in the direction of a "global" planet as a common world for collective problems such as scarcity and depletion of non-renewable sources and turn to "global" (and optimistic) technological solutions to deal with these problems. And these solutions might again be criticized by counter-narratives that show inflicted harm on a "local" level.

Overall, this example illustrates how a debate on climate change might not go further but will reach a stalemate. In the following subsection, we continue my attempts to disclose criteria for dealing with the climate issue. For this purpose, we analyse how scientific uncertainty is handled in a political statement from the Trump administration and we contrast this statement as a foil to illustrate how Trump's policy might also be anchored to the modern model. We then explore how

[19]Another group of voices would be the actors referred to as "they" who are unknown to us and should not be underestimated.

this condition of uncertainty disarms a core principle from this model reinstated in the main reaction conceptualized inside IFLS in the context of Trump's policy.

4.2 Letting uncertainty be displayed

In a brief interview in 2017, Scott Pruitt, new head of the US Environmental Protection Agency, stated the following:

> *I think that measuring with precision human activity on the climate is something very challenging to do and there's tremendous disagreement about the degree of impact, so no, I would not agree that it's a primary contributor to the global warming that we see... [...] But we don't know that yet ... We need to continue the debate and continue the review and the analysis (Pruitt, 2017).*

The statement is interesting for several reasons. First, *uncertainty* and dissent in scientific practice when measuring human impact on climate change are presented as a *problem* in order to practically dismiss the relationship between climate change and human activity. In addition, it is argued that more debate and research will solve the problem. The politicization of scientific uncertainty in environmental controversies, specifically in the climate change issue, has been a common practice during US presidential elections (Sarewitz, 2004). That uncertainty is politicized in this case to allegedly justify that other economic purposes may also be quite plausible.[20] Rather, the interesting point is that Pruitt's statement concurs indirectly with what has been identified as the "speaking consensus to power" approach (Van Der Sluijs, 2012), by which multiple and competing scientific perspectives in dissent need to be mediated into a consensus that works as a proxy for truth to inform policy in the best possible way. In other words, implicitly operating at the heart of this statement is the modern model[21] which holds the central belief that "valid, reliable, value-neutral and objective" knowledge produced by experts will tell us what to do and assumes that uncertainty can be eliminated or controlled. In this way, while political statements by the Trump administration (outside IFLS) implicitly operate according to the modern model, the main reaction inside IFLS reinstates a version of this model through a polarized narrative that has been conceptualized[22] as "*Climate change is a matter of science which has provided us with overwhelming evidence about the human impact on climate change. Science is about truth and facts...*" (Revisit the first section for a full description of this narrative).

[20] A general idea of the multiple unconscious brain mechanisms like repetition and use of metaphors to transmit lies can be found in Lakoff (2006).
[21] For a deeper analysis of the political accommodations within the modern model, see Funtowicz and Strand (2007).
[22] It is worth noting that in the analysis of the text corpus in IFLS, only two commentators mention uncertainty principles in climate science (replies to the entry posted by the website's administrator on 12 and 16 November 2016, respectively.

The suspicion arises because if a core principle from the modern model embedded in this predominant reaction implies that legitimate action should be based on having “value-neutral and objective” knowledge about predicting catastrophe in climate change, climate science and catastrophic predictions by the experts may not discover the truth or the almost truth to tell us what to do when dealing with this issue. The same condition of high uncertainty is connected with the future, that is, with the exact catastrophic predictions in the complex systems of the climate caused by human activity and, at the same time, with the exact prediction of the future consequence of an intervention in order to mitigate such catastrophic changes. In this way, the irreducible and inherent condition of high uncertainty breaks down the legitimacy of an action based in the prediction of the future (Funtowicz and Strand, 2011). What remains as legitimate grounding on which to base actions is what already exists and what “we” (as a community and collectivity) have: the present. Indeed, uncertainty may not be connected with a wrongdoing. In the climate issue, we usually know the right thing to do, for example, reduce pollution.

According to Funtowicz and Strand (2011), the problem of the lack of collective agency when dealing with the challenge of climate change can be found in the same expert prediction of catastrophe. Specifically, these scholars suggest that Arendt’s analysis published in 1951 could be extended not only to refugees, victims of war, the unemployed or industrialized labour, but to the contemporary context of the expertise that predicts catastrophic effects on climate change. In this regard, Arendt (2006, 1994) points to an experience of the modern masses since the Industrial Revolution that has been accentuated by the rise of imperialisms: loneliness that comes from uprootedness and superfluousness in modern industrial societies. She argues how this basic experience became fertile ground for the logic of totalitarian ideological thought to develop an unreflective obedience that was able to deprive human beings of all agency and even of identity and personhood in the concentration camps. When this analysis is extended to the context of expert predictions of catastrophe, these predictions are the outcome of an isolated form of productive work (knowledge and truth must be isolated from unqualified opinions, the community) and are thus not grounded in a collective agency. The prediction is only for those that execute technical intervention (be they a scientific or political elite). In this way, expert prediction is marginalizing an essential part of the present called our *praxis*, our political community life. Indeed, from this perspective, what might be at risk is not so much the planet, climate or natural resources, but, paradoxically, “we”, as a collective agency, that is, our human right of personhood and hope.

Interestingly, the great frustration over political inaction on the climate issue has provoked curious reactions by some institutional leaders. Strand (2015) analysed a statement on climate change from a speech given in 2007 by Gro Harlem Brundtland (at the time, the UN Secretary-General’s Special Envoy on Climate Change). Brundtland opted for a discourse of certainty: “what is new today is that doubt has been eliminated [...] the time for diagnosis is over. Now it is time to act". Strand speculates why Brundtland did not follow a more defensible discourse–say, "Science is telling us that the climate problem is extremely urgent and, of course, there may be uncertainty; however, this does not justify inaction and uncertainty may be a reason for precautionary action" (Strand, 2015: 205). Instead, Brundtland argues as if the uncertainty *is a matter of the past.*

5. Concluding remarks

The growing awareness of systemic crisis is understood in this chapter as signs of a deeper crisis of the modern model of legitimation (Funtowicz and Strand, 2007). Still, several reactions in academic, political and public spheres do not apparently appreciate the depth of the crisis since they reinstate different versions of this model. In this chapter, we have critically analysed the reactions on the social website IFLS in relation to the urgent concern of climate change after Trump's election.

Firstly, we have argued how the three main narratives identified in IFLS have their roots in old repertoires of demarcation from the modern model of legitimation, the public deficit model and narratives of scientific progress. Secondly, we have specifically challenged the main narrative conceptualized in IFLS to identify criteria for dealing with the climate change issue and open a dialogue space, since this narrative appears to lead to a growing climate of polarization.

On the one hand, a public dialogue on climate change between 1) those who hold the predominant narrative in IFLS (and might be prone to "global" technological solutions to combat this complex problem), 2) the group of actors referred to as "they" by the holders of this narrative and 3) those who criticize this narrative (and its particular "global" technological solutions) with a need to show inflicted harm on a "local" level, might experience a stalemate. This stalemate is associated with a cognitive incommensurability, which is closely connected to a growing awareness of the condition of complexity of the climate change issue and other environmental problems. The challenges posed by this condition require new forms of knowledge (and action) that start by releasing the desire to control that complexity and the ideal of (and wish for) *complete* scientific knowledge in order to make decisions. On the other, while Trump administration policy might also operate implicitly according to the modern model, the main reaction identified inside IFLS in the context of this policy reinstates a version of this model whose traditional Western recipe of having "valid, reliable, value-neutral and objective" knowledge about predicting catastrophe to tell us what to do (in the present) is falling apart. Precisely because knowledge was never neutral or objective and the same condition of high uncertainty in the complex climate issue disarms the legitimacy of an action based in predicting the future. What remains as legitimate grounding on which to base actions in societies that are likely to remain under considerable economic and environmental strain is what already exists: the present. In this regard, and paraphrasing

Funtowicz and Strand (2011), what is at stake when dealing with the climate issue is not so much the planet or natural resources, but that essential part of our political life in the present, namely, *our praxis*. Are we (as a community) willing to sacrifice that political life? How we can act in the present under knowledge conditions of high uncertainty and complexity in the climate issue is deeply intertwined with the values we want to preserve. This issue advocates reflexivity on our own Western biases and cultural assumptions, and virtue ethics in our political action.

5.1. APPENDIX 3: ADDITIONAL INFORMATION ABOUT THE QUALITATIVE ANALYSIS PROCESS.

Figure 1. Entry posted on 11 November 2016 on the social network “I fucking love science”.

“THERE IS A CULT OF IGNORANCE IN THE UNITED STATES, AND THERE HAS ALWAYS BEEN. THE STRAIN OF ANTI-INTELLECTUALISM HAS BEEN A CONSTANT THREAD WINDING ITS WAY THROUGH OUR POLITICAL AND CULTURAL LIFE, NURTURED BY THE FALSE NOTION THAT DEMOCRACY MEANS THAT `MY IGNORANCE IS JUST AS GOOD AS YOUR KNOWLEDGE´”. ISAAC ASIMOV.

Note: This entry was posted on 11 November 2016 in the form of quote. The original source of the quote is: Asimov, I. (1980). A Cult of Ignorance. *Newsweek*. January 21, p.19.

Table 19. **Codification and interrelation of categories in a pattern of interaction.**

Code	Category of interaction	F_i	Comment´s examples	Feature of the replay	
1	Yes, "we" agree.	17	- Come back and say it again, please! - Keep it coming IFLS!		Positive interactions (71,55 %)
1.1	Yes, "they" are ignorant, uneducated and are being proud of it.	91	- Not only does ignorance now rule the day, people are proud of being ignorant. - The sheer ignorance and blind stupidity of the USA never fails to amaze the civilised world. [...]. Do you not realise that you have elected an infantile bigot as your president? That your country has become a laughing stock throughout the world?	Further exploration of the entry	
1.2	Ignorance is a lack of scientific knowledge that could be solved with more education and science knowledge.	28	- Ignorance is the problem, and education is the solution. This includes education about the American electoral process [...]		
1.3	"They" are wilfully ignorant.	38	- In the face of overwhelming evidence, you choose to be wilfully ignorant.		
1.4.	"They" are a problem/threat for democracy	26	- It is amazing to me that the ignorant people burning and rioting have a vote that is just as valid as my knowledgeable and educated self. - This is not just in US, trust me...Democracy raises and falls with literacy, scholarship [...]. - If an under educated idiot chooses to not believe in climate change, even though it is actually real, should we that actually understand how things work allow the idiot to destroy our planet by inaction and ignorance?		
1.5	"They" are denying climate change and climate science. Science is neutral, about "facts" and is not related with beliefs or political parties.	115	- Science is neutral. If you love science you should concern that we just elected someone who is completely against intellect and science. - It´s the end of science as Trump prepares to put a climate change-denier in charge of the EPA [...]. Welcome to the post-truth nation. - Regarding evolution, climate change many people believe what they want to instead or reading the studies themselves. Though both have proved true, people would rather not be explained the details, so they can hold on to their preferred beliefs.		
1.6	"They" don´t believe in climate change/climate science	32	- Trump doesn´t believe in science (see his views on climate change, vaccinations etc). If you truly love science, then you should be worried by this.		
2	The entry is criticized because "certain arrogance of smart people".	61	- Don´t you think intellectual elitism was part of the problem. "I am smart, therefore, I must be a better person that you". - This is the problem with "smart" people. They look down on the rest of the population and think they are so much better. - How about we stop calling people ignorant and start listening to their issues and trying to find common ground.	Disagreements with the entry (25,77 %)	
3	The entry is not "scientific".	45	- IFLS please, get off of the politics and back to science. - Get back to posting science related material [...] - IFLS, you have proven to be not only uneducated and politically biased...But evidently not even scientific. Unfollowed.		

Interrelating categories and conceptualizing a pattern of interaction:

"They" (Trump, the elected politicians and the people who voted for them) are ignorant, uneducated and choose to be wilfully ignorant. They are denying climate science, which is neutral, about "facts" and has not political bias. "They" should be re-educated in science.

4	The entry is pandering to a liberal base.	7	- All IFLS is doing is pandering to a liberal base. [...].	
5	Less common explanations.	12	- Most voted for him because they refused to vote for her. - Trump is a disaster but less whining about how bad the situation is and little reflection as to why it happened. Was Hillary the best candidate establishment could provide? Or perhaps establishment is losing its grasp of reality and people are willing to elect whomever just to teach them a lesson. It´s time for self-reflection. - But Trump is not anti-science. He is not against NASA and exploration of space!	
6	There is not substantial relation with the entry	13		Rest (2,68 %)
	Total Comments	**485**		**100%**

Chapter 5.
General discussion and conclusions

This chapter is divided into five sections. In the first two we bring together and reflect on lessons learned from the study cases developed in Chapters 2, 3 and 4, to answer the two main research questions. In section 3, we suggest and reflect on cross-cutting lessons from the two main research questions. And in section 4, we make some concluding remarks on the debate to which we contribute. In the last section, we briefly indicate some lines for future research.

1. Answering the first research question

The first research question we asked was as follows: if, and in which ways, could innovation-based European policies be (re-)acquiring meaning when interacting with critical perspectives that highlight difficult nexus tradeoffs and socially inflicted harms? Specifically, we aimed to investigate the role played by innovation (as imaginary) when interacting with those critical perspectives, so that these interactions and relations could enable European policies to (re-)acquire meaning. We answer this question by bringing together lessons learned from Chapters 2 and 3 (section 1.1 and 1.2 below, respectively) and by reflecting on these lessons (section 1.3 below). Specifically, in the latter section we introduce two additional elements: the European subsidiarity principle and nexus thinking at low levels (e.g., local, regional), a specificity already inserted in section 4.1 in Chapter 1.

1.1 Lessons learned from Chapter 2

In Chapter 2, we discussed the idealised innovation-based discourse of the political EU2020 strategy, launched during an acute legitimacy crisis of the European project in the wake of the 2007–2008 financial crisis. Specifically, we argued how innovation (as sociotechnical imaginary) plays a central role in (and for) nexus governance within a neoliberal rationality aimed at relaunching the single market, expanding economic growth and (re-)legitimating the European project in that situation of crisis. On the one hand, innovation enables nexus concerns (framed as *European* concerns) to be translated into a discourse that promises "win-wins" (namely for the economy and the environment). In this sense, innovation "solves" a policy problem in that it brought about imagined win-win solutions at the discursive level *in* nexus governance. On the other hand, while this idealised discourse does extensive policy work by functioning as a "politics of truth", the innovations are actions-oriented and involve priorities *for* the biophysical nexus. That is, if the innovations were actually implemented on a large scale, they would involve the support of some policy targets over others, aggravating existing problems in the nexus or creating new (and unexpected) problems in other parts of the nexus.

Furthermore, we also argued how the idealised innovation-based discourse leads to specific policy work in society. The discourse upholds the conditions that do not act on inequality and threaten aspects of human well-being through subtle types of competitive mindset.

1.2 Lessons learned from Chapter 3

In Chapter 3, we developed a better understanding of the role of innovation (as imaginary) in its interactions with the nexus, so that such interactions might contribute to the (re-)shaping of the circular economy policy. This policy was formulated in the mid-2010s (European Commission, 2015, 2017) during a legitimacy crisis of the European institutions exacerbated, among other reasons, by the increasing election of so-called Eurosceptics to the European Parliament during elections held in 2014 and the referendum held in 2016 to vote on whether the United Kingdom would leave or remain in the European Union (European Union, 2021). By the time of writing this dissertation, this policy continues to be reformulated as has been manifested in recent communications (see, for instance, European Commission, 2020a).

Specifically, the circular economy policy's discourse that we zoom into (i.e., European Commission, 2017) simultaneously embraces several "challenges" (e.g., climate change, water management, waste management, pressure on natural resources, pollution) through different areas of Research and Innovation Policy. These challenges are nexus concerns that have been framed as *European* concerns. And we argued how innovation plays a very specific role as the central technical and political means that enables those nexus concerns to be translated into a discourse of win-win ideas (for the economy and the environment). More specifically, we argued how these ideas are mainly embodied in specific technical objects or processes at a level (Level I technology in Allenby and Sarewitz's terminology, 2013) that is considerably different from those nexus concerns that tend to be reflected at the system level of environmental governance. In this sense, the innovations are primarily introduced as ideas and imaginaries that embrace win-wins in nexus governance, and these ideas are mainly translated into specific technical objects and processes that tend to be relatively successful in the domain in which they are conceived (Level I technology). At the same time, the relative success at this level justifies a large-scale implementation of the innovations, which might create unintended new nexus tradeoffs or aggravate other parts of the biophysical nexus, because the innovations implicitly involve priorities for the biophysical nexus by supporting some policy targets over others. Still, the innovations are introduced without much importance being given to their destabilising role *for* the biophysical nexus or the unpredictable effects that their large-scale implementation might pose because they tend to be posed, precisely, at Level I technology.

Moreover, we learned how the innovation-based discourse of the circular economy contributes to the formulation of nexus concerns with the help of counternarratives and critiques such as the ecological economics perspective (Giampietro, 2019) that suggest difficult tradeoffs for the nexus even before the actual implementation of the innovations. Accordingly, the discourse of the circular economy policy might be rethought in its early stages of formulation by invoking the role of innovation identified so far, that is, one that enables nexus concerns (the outcomes of ideas posed at Level I) to be translated into a discourse of win-win ideas and imaginaries.

1.3 Reflecting on lessons learned

From the set of critical perspectives applied in Chapters 2 and 3, both political strategies—the EU2020 strategy and the circular economy policy—might be seen as non-precautionary because they postulate technocratic nexus governance. Nexus concerns might become scaled up and framed *as European concerns* by applying the principle of subsidiarity[23] and innovation, as a central technical means, enables those nexus concerns to be translated into very specific win-win ideas (posed at Level I technology). Accordingly, it might be more precautionary if the European project i) were openly recognised as an explicit political project that merely frames the nexus through techno-fixes at Level I within a neoliberal rationality aimed at building the single market and fostering economic growth and ii) kept the nexus(es) as a "matter of concern" (Cairns and Krzywoszynska, 2016). In this direction, recent literature has highlighted the need to establish the nexus as a legitimate policy problem in governance, pointing toward an institutional paradigm shift to boost the nexus as a matter of coordination of different political domains and sectors and progressively relinquish the traditional sectoral approach or "silo approach" (see, for instance, Volker et al., 2019).

At the same time, the innovation-based strategies might also be seen as increasingly risky because *if* those win-win ideas (posed at Level I technology) were implemented on a large scale, they could disseminate systemic failures in one sectoral domain toward related domains and across all implied policy levels. In the particular case of the circular economy policy, the implications *for* the biophysical nexus might be especially risky since the set of win-win ideas posed at Level I proposed within this policy encompasses several policy domains and sectors at once (e.g., building sector, industrial sector, agricultural and forestry sector, and so forth). In this sense, the innovation-based strategies would be "obscuring the political and economic drivers of unsustainable outcomes" (Cairns and Krzywoszynska, 2016: 166). In the case of the EU2020 strategy and from the Foucauldian perspective (Foucault, 2008) applied to critically analyse it,

[23] Key principle that regulates European competences and implies that "in areas which do not fall within its exclusive competence, the Union shall act only if and in so far as the objectives of the proposed action cannot be sufficiently achieved by the Member States, either at central level or at regional and local level, but can rather, by reason of the scale or effects of the proposed action, be better achieved at Union level" (European Union, 2008: 18).

this strategy might also be seen as dangerous because it promotes "one size-fits all" solutions since innovation is, for instance, (re-)invoked to deal with social problems through so-called "social innovation" (European Commission, 2010b: 14). Simultaneously, the EU2020 innovation-based discourse contributes to formulating social concerns, specifically about human well-being and social justice (e.g., upholding the conditions that do not act on inequality).

Furthermore, the innovation-based strategies might also be seen as having little sense *if* they were (re-)thought again by (re-)invoking "innovation" as the technical means to transform the nexus and social concerns (made visible through the help of our set of critical perspectives) into a discourse of win-win ideas embodied in techno-fixes at high-level European policymaking. Accordingly, it would be more precautionary if attempts were made to solve every problem at the level(s) at which the problem subsists through a more hopefully sustainable (and fair) solution. Indeed, those technological innovations proposed in the world of "high-level politics" might be seen as obfuscating real problems experienced by citizens locally or in the more immediate places where they live. More specifically, the innovation-based strategies might be criticised from the nexus-thinking perspective at these "lower" levels by applying the same European principle of subsidiarity with the order of relations reversed: the European level is only legitimate as long as it can serve actors at lower levels (national, regional or local). Indeed, this principle implies that decisions and actions should be taken as closely as possible to the citizens, that is, at the most immediate level consistent with the resolution of a political, social or environmental issue (although it does not exclude the possibility that this issue also has European solutions when appropriate). In this way, the critique suggests that the technological innovations proposed will run into local wicked problems, biophysical limits and pressure on local resources. The problems that the technological innovations are trying to solve might even be reflected as politically constructed problems deriving from "high-level" politics that are posed within a neoliberal rationality aimed at expanding economic growth and global markets. For instance, the large-scale implementation in several regions of Innovation 4 proposed in the circular economy policy that processes plant biomass (e.g., forestry products) into high-value market applications such as plastics (see Table 3 in Chapter 3) might generate potential nexus tradeoffs in terms of competition with other local land uses such as agriculture, even aggravating biodiversity loss in the long term. In this way, one might even reflect on the (regional) desirability of plastics production to keep economic growth on track, and in all likelihood, to be exported to other places.

Paradoxically, this type of critical analysis, by showing and making visible an overflow of potential nexus concerns on local and regional scales before the actual implementation of the innovation (indeed, there is no large-scale implementation for most of the innovations as shown in Table 4 in Chapter 3) might lead to a rethinking of the policy in its subsequent stages of reformulation by invoking the predominant role of innovation identified so far. That is, scaling up environmental problems and nexus concerns from local and regional levels to a European level through the principle of subsidiarity, and translating such concerns into specific win-win ideas posed at Level I to further consolidate the market-making and building of the political institutions. Indeed, the tensions and environmental problems deriving from economic growth (e.g., climate change, increasing pressure on natural resources) are intrinsic to the sustainability policies that the European Union has been dealing with, at least, since the Amsterdam Treaty in 1997 (European Commission, 2019c), which followed the tradition of the Brundtland Report (Brundtland,1987). In this way, the growing nature of cross-sectoral coordination frameworks of reformulations such as the i) reformulation of the circular economy policy announced in March 2020 (European Commission, 2020a) or ii) the so-called European Green Deal (European Commission, 2019b) *could make sense* in an accentuated crisis of legitimacy of the European institutions.

Our point with this reflection is that the set of (our) critical perspectives and analysis applied that show nexus concerns on a local scale, as well as the harm inflicted on society and for human beings (from the Foucauldian perspective applied in Chapter 2), can be thought of as *corrections* of institutional political strategies. In other words, the European institutions are trying to (re-)accommodate these critical perspectives (the majority of which are being increasingly characterised by an understanding of secondary effects, interdependences and uncertainties at the system level) in policymaking by devising strategies such as the recent reformulations of the circular economy policy or the European Green Deal (European Commission, 2019b, 2020a) via innovation as a central technical means. Indeed, this point can be reflected in the light of Gramsci's quote (2011) already introduced in Chapter 1: "the crisis consists precisely in the fact that the old is dying and the new cannot be born; in this interregnum morbid phenomena of the most varied kind come to pass" (Gramsci, 2011: 32–33). From the point of view of the (our) critical perspectives that advocate nexus governance in complexity (and social justice), policies such as the circular economy might be seen as a morbid phenomenon. Conversely, from the point of view of the proponents of these official policies, (our) critical voices might be regarded as morbid symptoms. These proponents might then try to accommodate critics by (re-)shaping and devising strategies that appear to be orderly policies against the background of a legitimacy crisis.

2. Answering the second research question

The second research question we asked was as follows: what are the possible roles of the idealised views of science on environmental issues that are (re-)invoked in emergent narratives in the public sphere, and how do these narratives interact with critical perspectives that advocate the acknowledgement of complexity and uncertainty? We answer this question by bringing results from Chapter 4 (section 2.1 below) and reflecting on them with the help of renewed insights from Strand (2002) (section 2.2 below).

2.1 Lessons learned from Chapter 4

In Chapter 4, we critically analysed the polarised narratives that emerge in the social media web "I fucking love science" (IFLS) in relation to the urgent concern of climate change and in reaction to Trump's election as president of the USA in 2016 (understood as a morbid symptom of the generalised crisis of legitimacy of the scientific and political institutions). We argued how the three most predominant narratives conceptualised in the social web are anchored to repertoires of demarcation from the modern model of legitimation, the public deficit model and narratives of scientific progress. We also critically challenged the most predominant conceptualised narrative that reinstates idealised views of climate science from the modern model, together with a version of the public deficit model, by claiming, roughly, that "climate change is a matter of science and science is about truth and facts, but they (the deniers) do not understand the science". Specifically, we applied two critical perspectives in a different way. On the one hand, we *reviewed* criticisms of the deficit model by Irwin and Wynne (1996) and argued how the public dialogue in the climate change issue between i) the holders of the most predominant narrative conceptualised in IFLS (that might be prone to "global technological solutions" to combat the environmental issue), ii) the actors referred to as "they" by the holders of this narrative and iii) those who criticise this narrative (and its "global technological solutions") by adopting Irwin and Wynne's critical stance might experience a stalemate of cognitive incommensurability (Strand, 2002). From this critical review, we concluded by pointing out the need for new forms of knowledge (and action) to deal with the complexity condition in the climate change issue. In this sense, we *suggested* starting by letting go of i) the desire to control that complexity and ii) the ideal of (and wish for) complete scientific knowledge in order to make decisions.

On the other hand, we *adopted* insights from Funtowicz and Strand (2011) to deploy criteria for dealing with the climate change issue under conditions of high uncertainty and complexity. Specifically, and with the focus on the condition of high uncertainty, we argued how this condition disarms a core principle from the modern model by which legitimate action is to be based on predicting future catastrophe in climate change to tell us what to do (in the present). From this critical perspective, we concluded then by pointing out praxis as a legitimate principle grounded in the present and on which to base actions when dealing with the environmental climate change issue. Specifically, we highlighted that what might be at stake is our praxis, as collective agency.

2.2 Reflecting on lessons learned

Strand (2002) proposes a distinction between "thin complexity" and "thick complexity", referring with the latter to aspects of the complexity associated with the contextuality, the emergent complexity and the value-ladenness addressed, for instance, by Funtowicz and Ravetz (1993, 1994). As for thick complexity, Strand (2002) does *not* try to propose a concept that encompasses different notions of complexity, but to explore some implications of statements that affirm the existence of thick complexity (e.g., the need for governance under thick complexity) to negate central beliefs of the "simple view" in science such as truth, objectivity, neutrality, and so forth (also read here for close similitude: beliefs from the modern model identified by Funtowicz and Strand, 2007). In this subsection, we *state* the presence of thick complexity (as something *outside* that cannot be grasped) to develop the answer for the second research question. Specifically, we start by *stating* the presence of thick complexity to discuss two main roles played by the idealised views and beliefs in climate science from the modern model (e.g., truth, facts, etc.) that are (re-)invoked in the most predominant narrative identified in the social web.

The first role is entangled with imaginaries (and desires) of control, power and complete descriptions of thick complexity. This role would be more naïve in nature, and those idealised views in (climate) science are a sign of how the "modern model" is profoundly culturally engrained in our societies. *The second role* played by those idealised views in (climate) science can be related with the phenomenon of "Desperate Modernity" (Strand, 2002), which implies that those idealised beliefs are retained exactly because of an awareness of the thick complexity (and the uncertainty associated with it) in the climate change issue. For instance, a scientific risk assessment of a technological innovation to deal with the climate change issue would not and cannot represent the uncertainties and complexities of the issue. However, to admit that might generate instability and fear. Accordingly, one might simply pretend to believe in those idealised views in science because "it is judged unsafe to stop pretending" (Strand, 2002: 9). In this way, one might simply pretend to believe that climate science will tell the truth (or almost the truth) about what to do under the thick complexity of the climate change issue.

Moreover, we critically analysed the most predominant narrative identified in the social web by using two critical perspectives (i.e., Irwin and Wynne, 1996, and Funtowicz and Strand, 2011) in a different way. In what follows, we reflect on *how* these critical perspectives interact with those previous roles of science identified above, displaying what specific principle for governance under thick complexity might be implied by Funtowicz and Strand's criticism. On the one hand, when we *reviewed* and reflected on Irwin and Wynne's (1996) criticisms of the deficit public model, we argued that the public dialogue on climate change might experience a type of stalemate of cognitive incommensurability (Strand, 2002). Why? First, the critical stance reviewed involves an acknowledgement of the (thick) complexity in environmental issues. However, in the face of this complexity, science and every solution deriving from it appear as imperfect, as if the solutions were to be judged according to some cognitive or corrective standard. Specifically, the criticism investigated tends to show (i) the one-dimensional, reductionist and standardised nature of science (its knowledge, the techniques and the global technoscientific solutions) to deal with a complex problem and (ii) that these techniques and solutions-based science are devastating to nature as well as to human beings on a local scale. In this way, the critical stance appears to be based on the need to show inflicted harm for which the criticised narrative can be blamed, and the discussions about environmental governance become difficult. On the other hand, we adopted a critical stance toward the narrative challenged by following insights from Funtowicz and Strand (2011). Specifically, we challenged a central principle from the modern model (which is (re-)invoked in this narrative), namely, that legitimate action is to be based on predicting future catastrophe on climate change. From this critical stance, the acknowledgement of high uncertainty about (i) future catastrophes on climate change and (ii) exact future consequences of actions to mitigate such catastrophes would entail letting go of the desire for predictability and control in climate change governance. Accordingly, the principle or criterion on which to base legitimate action in the face of high uncertainty and (thick) complexity would have to be grounded in the present. In this sense, high uncertainty in the climate issue would not stall effective climate action. For instance, the right thing to do would be to reduce pollution. The challenge would be how to do it as collective agency. Therefore, praxis is deployed as a necessary part of the present on which to base actions and as a principle at risk that is being marginalised by the expert prediction of catastrophe on climate change.

3. Suggesting and reflecting on cross-cutting lessons

In this section, we first suggest cross-cutting lessons from the two main research questions above and by reflecting *on* the set of critical perspectives applied in all the case studies (section 3.1 below). Then, we shall continue reflecting on these cross-cutting lessons (section 3.2 below) with special focus *on* the nexus thinking.

3.1 Cross-cutting lessons

From the first research question, we learned that the innovations are posed within a neoliberal rationality aimed at expanding economic growth and making the single market and that they are introduced primarily as win-win imaginaries and ideas for the environment (e.g., relieving the use of fossil fuel energy) and for the economy (e.g., maximising an economic utility for the single market). Specifically, we learned how innovation plays a specific role as a central technical means to translate nexus concerns into a discourse of win-win ideas at a level (Level I technology) which is different by degrees from those nexus concerns (reflected at the system level of environmental governance and from the point view of the complexity). On the other hand, from the second research question, we drew on the phenomenon of "Desperate Modernity" (Strand, 2002) and identified a possible role played by the idealised views in (climate) science (re-)invoked in the criticised narrative: those idealised views might be retained exactly because of an awareness of the thick complexity in the climate change issue and because it is judged unsafe to stop pretending to believe in them. In this case study, we also assumed that the criticised narrative could be prone to mobilising "global technological solutions" (read also here: technological innovation) in the governance of the climate change issue (read also here: nexus problem). Considering both lessons together, we can outline the following **first cross-cutting lesson**: in the face of the (thick) complexity of nexus concerns, to introduce a technological innovation in the policy discourse *is judged safe*, precisely because the technological fix is posed as a win-win idea which tends to be relatively successful in the domain in which it is introduced (Level I technology).

Moreover, in section 4.3 in Chapter 1, we already indicated an implicit parallel found between the nexus thinking and Irwin and Wynne's (1996) critical perspective reviewed in the case study developed in Chapter 4. This parallelism was expressed in the following sense: Irwin and Wynne's criticism (i) involves an acknowledgement of (thick) complexity when dealing with environmental problems (read also here: nexus problem) and (ii) tends to show the failure of scientific knowledge, techniques and "global technological solutions" to deal with those complex problems. Specifically, this critical stance tends to show that such techniques and solutions were devastating to nature as well as to human beings on a local scale. On the other hand, nexus thinking allows for (i) reflecting on environmental problems at the complex system level and (ii) opening a discussion of tradeoffs and concerns (especially on a local scale) deriving from certain techno-fixes proposed to deal with those complex problems. For instance, nexus thinking may lead to warnings about pressures posed by certain technological innovations on the biophysical funds of the biosphere (reconceptualised from nature, Giampietro, 2019) on a local scale. In this way, nexus thinking *also* warns about the harm to nature on a local scale.

In our case studies, this discussion on concerns and tensions *for* the nexus is indeed extensively illustrated in Chapter 3, when the innovations selected for the circular economy are critically analysed from the ecological economics perspective (Giampietro, 2019) and Allenby and Sarewitz's (2013) theoretical taxonomy. These criticisms share a similar feature to Irwin and Wynne's (1996) criticism: they also tend to show (and anticipate) *the failure* of the innovations (posed as win-win ideas at Level I) to solve complex nexus problems, which tend to be formulated at the system level of environmental governance. As for the feature that shows the harm to human beings posed by certain solutions in Irwin and Wynne's (1996) critical stance, the Foucauldian critical analysis of the EU2020 innovation-based strategy in Chapter 2 was *also* based on the experience of harm to human beings (i.e., inequity and threat to aspects of human well-being). Similarly, the critical analysis from Chapter 4, which targeted the most predominant narrative identified in the social media and inspired by Funtowicz and Strand's (2011) insights, reveals that praxis is being marginalised by the technical expertise on climate change and that this marginalisation involves a risk for personhood and hope. Considering the parallelisms between the outcomes of this set of criticisms and Irwin and Wynne's critical stance, we can draw the following **second cross-cutting lesson**: in the face of the (thick) complexity of the nexus concerns, every "global-high-level solution" (read also here: technological innovation) to the problem of governance will fail, and criticisms of the innovation-based strategies tend to be based on the experience of harm inflicted on nature (especially on a local scale) and/or human beings.

From the point of view of these criticisms, the innovation-based strategies should be abandoned since they are anchored to a "quick-fix" or "easy-fix" mentality and as such may inflict collateral harm on nature as well as on human beings. Global institutions might, in this sense, be seen as producers of harm. How might nexus governance then develop to create fewer problems? From the complexity point of view, nexus thinking is precautionary and would make visible numerous biophysical interconnections between things (especially on a local scale). Truly precautionary governance would warn about the limits and the need to respect the renovation and regeneration of the biosphere's biophysical resources (Kovacic et al., 2019). In the light of Gramsci's quote (2011) introduced in Chapter 1, the new that apparently cannot be born would be a type of civilisation that would manage to live in less tension with the biosphere and destroy less of it, as well as to acknowledge the complexity of the biophysical nexus and pay respect to other living beings.

3.2 Reflecting on cross-cutting lessons

From the two cross-cutting lessons above, however, actions at the "highest levels" of politics resonated with a sense of urgency posed by the original nexus concerns, and desperate technocratic governance of the nexus was deployed. This type of governance contributed to creating more nexus concerns, aggravating the sense of urgency (which might lead to a dysfunctional governance). Faced with this predicament, how could "we" (from the point of view of nexus thinking and precautionary prescriptions for governance) drop that sense of urgency that leads to a dysfunctional governance? [24] To answer this question, we (i) draw a parallel between the Dao, from ancient oriental perspectives (Kovacic et al, 2019), and the nexus.

In Daoist philosophy, Dao can be translated as "way" and it refers both to nature (Nature's Way) and humans (as a chosen way of life based on virtues and practices). In relation to nature, a fundamental insight within this philosophy is that we should not confuse nature (the universe or the world) itself with our human concepts and descriptions of it. In this sense, nature is more complex than our understanding and escapes a full description. The real Dao then is that which cannot be comprehensively named or exhaustively described. Descriptions and concepts are used to pursue our desires, and both (descriptions and desires) are connected to will, power and

[24] A similar question has been raised in the final chapter of the book by Kovacic et al. (2019:180). To answer our question, we shall also take insights from the ancient oriental perspectives on governance introduced in this book.

solutionism. In this way, we build a parallel between the Dao and the nexus, in the sense that the nexus is characterised by a complexity that escapes full understanding and can also refer to a chosen way of practice, virtues and actions.

From this parallel, (non-dysfunctional) nexus governance would have to overcome the pursuit of power and control over complex nexus concerns and, thus, the *desire* to evaluate everything as useful or useless, good or bad, right or wrong. Overcoming these desires might be, then, a way to overcome the sense of urgency. At the same time, this does not mean remaining passive. Rather, when faced with the complexity of the nexus (and its associated uncertainty), we might plan less because there is uncertainty associated with the future and, thus, things may not go according to the will of the planner (this insight was, indeed, embedded in Allenby and Sarewitz's (2013) theoretical taxonomy applied in Chapter 3 by referring to unpredictability and complexity at the system level of environmental governance). This also means that we might be less afraid of the result of our actions because we would not be capable of evaluating correctly what is good and bad in any case. That is, the consequences of action will not be the evaluation criterion because there is uncertainty associated with the future, which cannot be decided or controlled. Indeed, one could imagine attempts to construct and plan a sustainable future by implementing knowledge at the system level and subjecting and coordinating the actions of all citizens that consume and emit at the same level. To paraphrase Kovacic et al. (2019): it is not obvious that an eco-totalitarian state à la Hitler is to be preferred to human extinction, ultimately deriving from our own destruction and the collapse of biophysical funds.

If one cannot decide how the world should be, a principle of action is involved within nexus governance *in* complexity, which is grounded in the present. That is, one would know the virtuous thing to do (in the present): the nexus concerns are the result of human actions and if our human civilisation desires long-term survival on this planet, it should respect the biophysical processes in the biosphere and stop disrupting them, even though that cannot guarantee a sustainable and bright future. Quoting Kovacic et al. (2019): "Where it leads, nobody can know; but we do not have to know" (Kovacic et al., 2019: 184). We arrived at a similar conclusion when we applied the critical stance inspired by Funtowicz and Strand (2011) in Chapter 4. Specifically, we pointed out the need for praxis (as an essential part of the present on which to base actions) when dealing with the climate change issue in conditions of high uncertainty and complexity. We also indicated that one would know the right thing to do (e.g., reduce pollution). The challenge would be how to do it through collective agency.

Following Latour's (1998, 2007) insights, we can identify a paradox involved in this principle of action that is implied by nexus governance in complexity. Latour (2007) argues that our modern societies and institutions coevolved under an intellectual ideological work (called work of purification) that pretends to separate "nature" from "society", "politics" from "science", "facts" and "values". Simultaneously, this type of work allows for an intensive process of mediation by which more hybrids and facts (made by humans) are realised. Latour (1998) has also argued that political ecology is implicitly anchored to the ideological work of purification in the sense that the voices of political ecology talk discursively, as if nature should be left alone and imperturbable. This rhetoric is usually expressed in terms of the global and the universal, but environmentalist action is interventionist both in society and nature through regulations, changes to things and so forth. According to Latour (1998), it is on these local scales where ecological critique, practice and action usually work best. These insights by Latour also resemble the principle of action expressed above, in the sense that the nexus involves tensions with the biosphere (read also here: nature), and the principle of action within nexus governance implies that the biosphere should be left alone and should be less disrupted by our societies. At the same time, the discussion of nexus tradeoffs tends to be reflected on a local and regional scale, where environmental problems are usually lived as experiences. Accordingly, it is at these levels where the problem should be solved and action should be taken (in the present), although it cannot guarantee a sustainable future.

4. Our contribution to the debate

In our dissertation, we have investigated three political processes: two official innovation-based policies in the institutional sphere and narratives that promote idealised views of science in the public sphere. Specifically, we have applied several critical perspectives for didactic purposes, including reflecting (and being more aware) on our own western action bias involved in the critical stances since they might reinforce what is being criticised (Latour, 2007).

As we moved forward in developing the case studies, answering the two main research questions above and reflecting on the critical perspectives applied in all the case studies from a cross-sectional angle, we became aware that the acknowledgement of uncertainty and of the need for praxis, as well as the need for nexus governance *in* complexity are, indeed, modern, but a type of reflexive modernisation à la Ulrich Beck (Beck, 1992). This means a type of modernity that reflexively and critically analyses the grand narratives of modernity about scientific progress, economic growth, innovation and technological development.

This also means that, in line with the conclusions obtained above, the set of critical perspectives we applied by highlighting harm to "nature" and "society" can be thought of as *corrections* of the institutional political strategies and grand narratives of scientific progress via innovation as a central technical means. That is, our modern institutions would be trying to implement and (re-)accommodate our critical perspectives (which are increasingly incorporating an understanding of systemic perspectives, uncertainties, unpredictability and unforeseen consequences, among other characteristics) in policy making via innovation as a central technical and political means.

In this sense, our dissertation contributes to a better understanding of how our modern institutions of governance are working and the official policies are being (re-)shaped.

Simultaneously, the dissertation contributes to the debates about sustainability and environmental governance that (i) might advocate governance in complexity of the nexus or (ii) raise questions such as what kind of science do we want for the governance of practical problems under conditions of complexity and uncertainty? Specifically, we contribute a negative message which we also hope will be constructive. The negative message is that we have not succeeded in providing general recommendations for nexus governance in complexity. Conversely, our recommendation would be that questions like the one raised above need to be reviewed since its formulation is indeed modern, though in the sense of reflexive modernisation suggested by Beck (1992). We also recommend adopting a more self-critical stance toward the nexus and opening a dialogue on what kind of governance and theory of change and action we want in light of the paradoxes presented.

5. Future research

Through this dissertation we have presented several paradoxes by researching three policy processes. In the particular case of the innovation-based European strategies, the policies which have been the object of study represent only two instances of the political discourses within the extensive political framework of the European institutions. In this sense, there is a need to continue exploring, systematising and developing a deeper understanding of how the environmental, economic and social issues are being governed, with special focus on the role of the imaginary of innovation in these governance processes. Overall, our dissertation is a stepping stone toward opening future lines of research that will adopt a reflexive and moral stance toward our institutions of governance and, through this research, (re-)think the governance and theory of change we want.

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