UNIVERSIDAD COMPLUTENSE DE MADRID
FACULTAD DE CIENCIAS ECONÓMICAS Y EMPRESARIALES

TESIS DOCTORAL

Ensayos sobre la dinámica causal entre la desigualdad, la pobreza y el crecimiento económico en los países de la Unión Europea
Essays on the causal dynamics between inequality, poverty and economic growth in the European Union countries

MEMORIA PARA OPTAR AL GRADO DE DOCTOR

PRESENTADA POR

Celia Gil-Bermejo Lazo

DIRIGIDA POR

Jorge Onrubia Fernández
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MEMORIA PARA OPTAR AL GRADO DE DOCTORA

Doctorado en Economía

PRESENTADA POR

Celia Gil-Bermejo Lazo

Directores

Jorge Onrubia Fernández y Antonio Jesús Sánchez Fuentes

Madrid

A mis padres, Esther y Jose, a mi hermano Andrés y a Julián

Agradecimientos

La práctica totalidad de la tesis se ha producido en el Instituto Complutense de Estudios Internacionales, que ha supuesto un entorno y ambiente fundamental para el desarrollo de este proyecto y donde he tenido la suerte de aprender muchísimo. Allí, tengo muchas personas a las que quiero agradecer su apoyo y sin las que, seguro, esta tesis sería muy distinta. Quiero comenzar agradeciendo a todos los compañeros que, en un momento u otro, han pasado por "la sala de investigadores". Aunque son demasiados para nombrarlos a todos, quiero hacer especial mención a quienes me han acompañado en estos últimos meses: a Hugo, Frank, Miguel, Gloria, Katty y Gonzalo quiero agradecerles su compañía y, sobre todo, su apoyo a lo largo de la tan dura etapa final. Por supuesto, quiero agradecer también al personal de administración y servicio, quienes con su trabajo han facilitado enormemente el mío y con su simpatía me han hecho más fáciles los días difíciles. Asimismo, quiero agradecer a la Dirección del ICEI, a Isabel y Jesús, haberme brindado la oportunidad de formar parte de un proyecto como el que han desarrollado. No se me ocurre un ambiente mejor para comenzar la carrera investigadora.

Los momentos en los que no estuve en el ICEI tuve la suerte de poder integrarme en el equipo de Euromod en el Joint Research Centre, quienes tan amablemente me acogieron y me hicieron sentir como en casa. En especial, quiero agradecer a Fidel toda la ayuda que me ha prestado.

También quiero agradecer a mis compañeros y amigos en el ámbito universitario la compañía y momentos que hemos pasado juntos. A Najat, sin duda, por las risas y complicidad que compartimos. A Luis, Dani y Javier, que además de compañeros y amigos han sido mis primeros editores, por prestarse siempre a escuchar mis preguntas y darme su opinión sincera.

A Jorge y a Jesús, mis directores, quienes sin ninguna duda han sido fundamentales para que yo haya conseguido llegar hasta aquí, a completar una tesis y escribir estas palabras, quiero agradecerles muchas cosas. Quiero agradecerles que confiaran en mí para llevar a cabo este proyecto prácticamente antes de que yo misma lo hiciera. Quiero agradecerles el apoyo inquebrantable que siempre me han trasmitido y las oportunidades que me han brindado. Quiero agradecerles la paciencia infinita ante mis divagaciones, pero sobre todo ante mis dudas. Quiero agradecerles la generosidad con la que siempre me han tratado, tanto en lo académico como en lo personal. Siento que es una suerte haber podido aprender de ellos a lo largo de estos años en lo profesional, pero especialmente en lo humano. En esta nueva etapa que comienzo, confío y espero en poder seguir aprendiendo con y de ellos.

A mis amigos quiero agradecerles el apoyo y la paciencia, y quiero pedirles disculpas por las ausencias que han sido daños colaterales de la tesis. A Edu, que estuvo desde el principio, cuando esto no era más que una idea que me rondaba la cabaza, y no ha parado nunca de animarme. A Luc y Caroline, quienes con la alegría que trasmiten siempre han conseguido que me libere de agobios y angustias. A José Miguel, quien pasó de ser un ingeniero renegado a un profe renegado y con quien espero seguir compartiendo el resto de cosas de las que reniegue. A Marta y María, quienes fueron mi primera segunda familia. A Javi, quien aparece aquí por decreto y por derecho, por haberme acompañado a lo largo de todos estos años desde que un día cualquiera, un profesor de una asignatura de primero de grado de economía tuvo a bien sentarnos juntos y él tuvo a bien ofrecerme unos folios reciclados. A Andoni, quien con su forma de ver la vida contagia de alegría a todos los coincidimos con él. A Marina, con quien he tenido la enorme suerte de compartir todas las etapas educativas y vitales, quien está por estas fechas terminando también su doctorado, por comprenderme y apoyarme siempre.

A Julián, Paqui y Pablo quiero agradecerles que me abrieran las puertas de su maravillosa familia desde el primer momento. Su ayuda, a todos los niveles, y cariño han sido fundamentales para mí a lo largo de todo este periodo.

Por último, quiero agradecer a mi familia, que constituyen la piedra angular de mi vida. A mis abuelos, por enseñarme con su ejemplo las formas de amor más desinteresadas e incondicionales con las que nunca me he encontrado. A mi abuela Ignacia, por ser un ejemplo de fortaleza y resistencia. A mi abuelo Jesús, a quien echo de menos todos los días, por trasmitirme la importancia del rigor, el saber y la cultura. A mi abuela Maru, por no dejar nunca de recordarme la importancia de ser bueno con los demás, por su cariño y generosidad infinitos y, sobre todo, inmutables. A mi hermano Andrés, quien pese a ser el pequeño me ha enseñado a vivir más la vida fuera de los libros y a ser valiente y dudar menos a la hora de enfrentarme a nuevas experiencias. Además, por su gran sentido del humor, que hace que sea la persona con la que más risas comparto. A mis padres quiero agradecerles tantas cosas que no sé por dónde empezar. Por abrirme las puertas y guiarme hacia la curiosidad y la reflexión sobre el mundo que nos rodea. Por no haber parado en ningún momento en su empeño por mi formación y educación. Por haberme enseñado tantas cosas que definen la persona que hoy soy. Por todos los sacrificios que han hecho por mí. A Esther, mi madre, por haber sido siempre para mí un ejemplo de mujer fuerte y valiente. Sinceramente creo que el camino recorrido para llegar hasta aquí comienza con ella, leyéndome los primeros libros antes de dormir. A mi padre, Jose, por haberme transmitido la satisfacción que se encuentra en la introspección, la calma de estar con uno mismo y la fortaleza para ser fiel a las opiniones propias. En todo lo que yo haga y en todo lo que yo consiga van a estar siempre ellos.

A Julián, con quien he vivido tantas cosas que resulta difícil transformarlas en palabras. Sin su inteligencia, pero especialmente sin su generosidad para ayudar a los demás, es muy probable que esta tesis, y que yo misma, fuéramos muy distintas. Creo que a lo largo de todo este periodo he tenido mucha suerte en distintos aspectos, pero sin duda, nada puede compararse a la suerte de haber coincidido en el ICEI, cuando él estaba a punto de finalizar su tesis y yo tan solo comenzaba la mía. Mientras termino de escribir estas palabras puedo ver el puesto en el que se sentaba cuando nos conocimos, pienso en el camino que hemos recorrido y en lo que está por venir. Y siento que mientras podemos seguir compartiendo bromas, reflexiones, trabajo y, al fin y al cabo, la vida, todo estará bien.

List of figures

List of Tables

Contents

Resumen

Esta tesis tiene el objetivo de analizar las relaciones de causalidad entre desigualdad, pobreza y crecimiento económico para las economías europeas durante el periodo 2003-2019, poniendo énfasis en el rol que los estados de bienestar -entendidos como sistemas públicos de prestaciones e impuestos- podrían estar jugando en la configuración de estas relaciones. Para ello, la tesis se divide en dos bloques fundamentales. El primero desarrolla una propuesta metodológica novedosa para analizar relaciones de causalidad a partir de modelos de Vectores Autorregresivos (VAR), en un contexto de datos panel y en conjunción con la aplicación de técnicas de modelos gráficos y mapas causales. Este bloque se complementa con dos ilustraciones empíricas que suponen contribuciones autónomas a sendos ámbitos de la investigación económica, relacionados ambos con la dinámica de formación de precios, diferentes del que ocupa el lugar central en la tesis que se presenta. El segundo de los bloques retoma el objetivo que vertebra la tesis y se concreta en un análisis aplicado. Para ello, en un primer estadio, se examinan las relaciones de causalidad entre los fenómenos mencionados al comienzo (desigualdad, pobreza y crecimiento económico) para Europa en su conjunto. Seguidamente, se lleva a cabo un análisis clúster a partir del cual se propone una nueva taxonomía de estados de bienestar europeos. A partir de esta taxonomía, se lleva a cabo de nuevo el análisis causal, subdividiendo la muestra según los tipos de estados europeos obtenidos.

Abstract

This thesis aims to analyse the causal relationships between inequality, poverty, and economic growth in European economies during the period 2003-2019, emphasizing the role that welfare states—understood as public tax-benefit systems —may play in shaping them. To achieve this, the thesis is divided into two main sections. The first section develops a novel methodological proposal for analysing causal relationships using Vector Autoregression (VAR) models within a panel data context, combined with the application of graphical models and causal maps techniques. This section is supplemented by two empirical illustrations that make autonomous contributions to distinct areas of economic research, both related to price formation dynamics and thereby different from the central focus of the thesis. The second section returns to the main objective of the thesis and is devoted to an applied analysis. In a first stage, causal relationships between the aforementioned phenomena (inequality, poverty, and economic growth) are examined for Europe as a whole. Subsequently, a cluster analysis is conducted, leading to a new taxonomy of European welfare states. Based on this taxonomy, the causal analysis is then repeated, subdividing the sample according to the identified types of European welfare states.

Introducción

Esta tesis doctoral se centra en estudiar, desde una aproximación dinámica, la relación existente entre el crecimiento económico y los fenómenos distributivos de la desigualdad y la pobreza. Como caso de estudio, los análisis empíricos realizados están centrados en las economías europeas durante el periodo 2003-2019. Este periodo es de especial interés porque está caracterizado por los profundos cambios que se producen a nivel macroeconómico, desde los años de crecimiento económico sostenido previos a la Gran Recesión que experimentan gran parte de las economías, a la abrupta interrupción de esta senda de crecimiento derivada de los efectos de la crisis financiera y la consecutiva crisis de deuda soberana que sufrieron parte de las economías de los denominados Estados periféricos, así como los efectos de la aplicación de las políticas de austeridad posteriores, hasta adentrarnos en el posterior periodo de recuperación.

Para ello, esta tesis se ha estructurado en dos bloques fundamentales. El primero, de carácter metodológico, se ha centrado en proponer un nuevo enfoque para analizar relaciones de causalidad en entornos de datos de panel a través de modelos VAR, lo que nos permite identificar tanto el impacto directo de una dimensión hacia las demás, como los impactos indirectos producidos a través de otras variables que actúan como "mediadoras". Al tener un carácter trasversal, este primer bloque se ha complementado con dos ilustraciones que revisitan literaturas clásicas de carácter macroeconómico, que sin estar directamente relacionadas con la temática principal de la tesis, sirven para ilustrar las ventajas que nuestro enfoque puede proporcionar en términos analíticos en comparación con los estudios previos.

El segundo bloque aplica la propuesta metodológica al tema principal de análisis de esta tesis: las relaciones causales en términos dinámicos entre la desigualdad de la renta, la pobreza monetaria y el crecimiento económico en las economías europeas durante el periodo de Unión Monetaria. Para ello, el segundo capítulo pone el foco en un amplio grupo de economías europeas para tratar de comprobar si podemos extraer dinámicas conjuntas que transciendan lo obtenido para un país y periodo concretos. El tercer y el cuarto capítulos, sin embargo, ahondan en las potenciales diferencias que pueden existir en dicho patrón de relación, vinculando, por ejemplo, esas diferencias a los distintos tipos de sistemas de prestaciones e impuestos instaurados en cada territorio. Para ello, como contribución previa, el capítulo tercero se dedica a proponer una clasificación de los países europeos novedosa, que basamos en las similitudes entre sus sistemas de prestaciones e impuestos y, más concretamente, en cómo estos afectan a la distribución de la renta de los hogares. O sea, valoramos no tanto las características formales de dichos sistemas sino los efectos que terminan provocando en la redistribución de recursos y, consecuentemente, en el bienestar de los distintos colectivos. El capítulo cuarto, combina el enfoque desarrollado e implementado en el capítulo 2 con la clasificación obtenida en el tercero, lo que nos permite culminar nuestras respuestas a la pregunta de investigación inicialmente planteada.

Si bien existe una clara continuidad entre los bloques y capítulos que conforman la tesis, también existe una vocación de independencia entre cada uno de los capítulos, de forma que se ha pretendido que fuera posible entender cada uno de ellos por separado. Es por esto que fragmentos parciales de distintos capítulos pueden ser similares.

Literatura académica sobre el vínculo entre el crecimiento económico, la desigualdad y la pobreza.

Uno de los temas de investigación económicos que más interés ha suscitado en los últimos años ha sido la naturaleza de la relación entre el crecimiento económico y distintas variables distributivas -siendo la desigualdad el fenómeno que más atención ha acaparado-. En este sentido, el debate académico ha seguido, fundamentalmente, dos enfoques. Por un lado, parte del esfuerzo se ha dirigido bien a plantear distintos modelos teóricos que capturaran los efectos macroeconómicos que se derivaban de la desigualdad, bien a modelizar las consecuencias distributivas generadas por distintos modelos de crecimiento. Por otra parte, la literatura ofrece numerosos estudios empíricos que han dedicado parte del esfuerzo investigador a contrastar la validez de estos modelos en distintas economías y diferentes momentos del tiempo.

En el ámbito teórico, las aportaciones de los diferentes autores han planteado tanto modelos que predicen un efecto positivo de la desigualdad sobre el crecimiento económico, impulsándolo, como modelos que pronostican el efecto contrario, en los que la desigualdad afecta negativamente al crecimiento económico. Entre los primeros, destacan como mecanismos fundamentales de trasmisión los incentivos que son percibidos por los agentes que, bien mediante un aumento del esfuerzo o bien mediante una asignación de recursos más eficientes, incentivan el crecimiento *(Hipótesis de los incentivos)*. Por el contrario, los trabajos teóricos que sostienen que la desigualdad tiene efectos negativos sobre el crecimiento económico señalan, sobre todo, al conflicto social, la inestabilidad política y el desaprovechamiento del potencial capital humano como transmisores principales *(Hipótesis de las oportunidades)*.

En cuanto a las contribuciones empíricas, una de las principales aportaciones que inaugura una larga tradición de estudios es el trabajo seminal de Kuznets (1955). En esta, el autor apreciaba una relación cuadrática entre ambos fenómenos, lo que se ha conocido como *La curva de Kuznets,* diferenciando según la etapa de desarrollo en la que se encontrasen los países, concluyendo que, si mayores niveles de desigualdad eran una característica habitual de economías en estados iniciales de desarrollo, esta tendencia se volvía del signo contrario una vez que las economías transitaban a estadios de desarrollos más avanzados. Posteriormente, se han ido desarrollando distintas modificaciones a esta hipótesis, entre la que destaca la literatura de *crecimiento pro-pobres.* La principal aportación de esta literatura consistió en plantear modelos en los que la relación se contemplaba desde la perspectiva del crecimiento económico. Si este reducía la desigualdad, se establecía que el proceso de desarrollo económico favorecía una reducción de la

pobreza -*crecimiento pro-pobres*-. Si, por el contrario, la desigualdad aumentaba, esto favorecía un aumento de la pobreza -*crecimiento pro-ricos*-.

A partir de estos trabajos seminales, se han sucedido numerosos análisis que trataban de contrastar la validez de estas hipótesis. Sin embargo, parte del desarrollo de esta rama de la literatura empírica ha estado profundamente condicionada por la disponibilidad de datos. Es por ello que habría que esperar a los años noventa para que comenzaran a publicarse trabajos que pusieran el foco en un grupo suficientemente amplio de economías. En un primer momento, dada la inconsistencia de las series temporales, la mayor parte de análisis aplicaban técnicas econométricas de sección cruzada adoptando un enfoque de estática comparativa. Alesina y Rodrick (1994) seleccionan un total de entre 46 y 70 economías entre 1960 y 1958; Persson y Tabellini (1994) se centran en 56 economías también entre los años 1965 y 1980; Clarke (1955) lleva a cabo su ejercicio para un número elevado países (entre 74 y 81), para los años setenta y ochenta, dependiendo de la disponibilidad de datos. Deininger and Squire (1998), a su vez, proponen su propia base de datos para un periodo total amplío (1960-1992) incluyendo información sobre un número también alto de países (entre 68 y 80). Castelló-Climent y Doménech (2002) amplían el número de países a entre 67 y 83 entre los años 1960 y 1990. Knowles (2005), para el mismo periodo, incluye un total de 40 economías. Sin alcanzar un consenso total, sí concluyen la mayor parte de estos estudios que el efecto de la desigualdad sobre el crecimiento económico es negativo.

A partir de los años dos mil, a medida que mejora la compilación y consistencia de la recogida de datos, empiezan a sucederse los trabajos que adoptan técnicas econométricas para datos de panel sobre distintos intervalos de promedios de años. Deininger and Olinto (2000) incluyen entre 31 y 60 economías en distintos momentos del periodo 1966-1990. Forbes (2000) se centra en analizar la relación para 45 economías diferentes entre 1965 y 1995. Barro (2000) lleva a cabo su estudio en el mismo periodo, pero analizando 84 países. Banarjee y Dufflo (2003) analizan 45 países entre los años 1960 y 1990.Voitchovsky (2005) se centra en 21 países desarrollados durante el periodo 1975-2000. Castelló-Climent (2010) incluye un total de entre 56 y 102 países durante el periodo 1960-2000. Ostry, Berg y Tsangarides (2014) se centra en el periodo 1960 - 2010 y analiza un total de 90 economías, Halter, Oechslin and Zweimuller (2014) analizan el mismo número de economías para el periodo 1966- 2005. La mayor parte de estos estudios optan por utilizar estimadores del tipo System-GMM, aunque también abundan los modelos de efectos fijos y aleatorios. Sin embargo, a pesar de la amplia producción académica dedicada a analizar los mismos periodos o cercanos, puede decirse que sus resultados no han permitido obtener un consenso concluyente acerca de la naturaleza del fenómeno, ya que se hallan tanto efectos positivos como negativos.

Finalmente, aunque menos numerosos, han surgido también algunos análisis más cercanos al enfoque seguido en esta tesis doctoral. En concreto, aquellos que se cuestionan qué variable ejerce el liderazgo en la relación significativa de dependencia que podamos identificar. Por este motivo, creemos que una alternativa metodológica para resolver esta indeterminación de la relación es afrontar su análisis en términos de la causalidad *à la* Granger. Así, Atems and Jones (2015) proponen un modelo VAR bivariante para los diferentes Estados de Estados Unidos con el que examinan la posible bicausalidad entre la desigualdad y el crecimiento económico. Por su parte, Grigoli, Paredes y Di Bella (2016) analizan la posible endogeneidad entre ambos fenómenos para una muestra de 70 países a lo largo de un periodo de 20 años, teniendo en cuenta tanto la variabilidad temporal como la heterogeneidad entre países. Brida, Carrera and Segarra (2020) llevan a cabo un análisis dinámico de causalidad à la Granger, pero utilizando técnicas no paramétricas que permiten clasificar a los 38 países incluidos en su estudio en distintos clústeres.

Asimismo, existe también un importante número de trabajos empíricos dirigidos a cuantificar el impacto del crecimiento económico en la reducción de la pobreza, habitualmente basados en el cálculo de elasticidades. De esta forma se establece un vínculo entre el crecimiento de las rentas más bajas de una economía y el crecimiento medio de la renta. Por lo general, el consenso en esta rama de la literatura es mucho mayor que el hallado para el caso de las investigaciones empíricas sobre la desigualdad, siendo habitual encontrar un efecto positivo del crecimiento económico sobre la reducción de la pobreza ("crecimiento pro-pobres") (Dollar y Kraay, 2002; Dollar et al., 2016). Sin embargo, por la construcción del propio enfoque, nada se puede decir sobre cómo afecta la pobreza al crecimiento. Por su parte, Adams (2004) y Ravallion y Chen (1997) estiman la elasticidad crecimiento-pobreza para una selección de países en desarrollo, obteniendo un rango de impacto de entre el 2% y el 3%. Otros intentan explicar las distintas magnitudes del efecto atendiendo al tipo de crecimiento, principalmente a través de la composición sectorial, o examinando las condiciones económicas iniciales. Entre otros, Loayza y Raddatz (2010) analizan el efecto del crecimiento económico en la reducción de la pobreza a varios niveles de desagregación de la producción para un grupo de países en desarrollo. Ferreira et al. (2010) realizan un ejercicio similar, centrándose en Brasil. Mussida y Sciulli (2022) analizan la dinámica de la pobreza en distintos momentos del ciclo económico -pre y post crisis- para una serie de países europeos.

A pesar de lo prolífico de esta literatura, gran parte de estos estudios comparten rasgos comunes que pueden explicar la diversidad de resultados obtenidos en la misma y que, además, fundamentan gran parte de las decisiones adoptadas en esta tesis doctoral. Empezando por el ámbito económico, la mayor parte de ellos se han centrado en economías en vías de desarrollo o, por el contrario, en una amplia muestra de países con estructuras económicas heterogéneas. En cambio, aunque resulte algo llamativo, los estudios que han puesto el foco de atención

exclusivamente en economías desarrolladas y en países 'ricos' no son tan numerosos, lo mismo que los dirigidos a aquellos países que comparten una estructura político-económica, como es el caso de los Estados miembros de la Unión Europea.

Por otra parte, como se demuestra en los trabajos anteriormente mencionados, la gran mayoría de estudios abordan únicamente una solo de las dos dimensiones distributivas consideradas y su relación con el crecimiento económico. Sin embargo, pensamos que tanto la pobreza como la desigualdad son fenómenos que pueden estar íntimamente relacionados, teniendo efectos la una sobre la otra, sobre todo cuando se cronifican ciertos desequilibrios en el medio o largo plazo.

Asimismo, otro de los aspectos comunes en esta rama de la literatura ha sido el enfoque, predominantemente de estática comparativa, dejando algo al margen la estructura dinámica. Precisamente, esta dinámica es que pretendemos capturar en la a través del uso de las técnicas de causalidad *à la* Granger. Así, incluso en los casos en los que se han utilizado estructura de datos de panel, en la mayor parte de los trabajos publicados se suele optar por promediar distintos años y comparar dichos promedios.

Por último, aunque quizás pueda considerarse una cuestión algo menor, otro posible factor a menudo señalado como responsable en este tipo de estudios de la heterogeneidad de los resultados producidos es el relacionado con las distintas fuentes de datos a partir de la cuales se calculan los diferentes indicadores de desigualdad o pobreza, que a menudo difieren en cuanto cobertura, unidad observacional o definición de renta elegida.

En este sentido, y dado que el debate continúa abierto tanto en foros académicos como institucionales o sociales, en esta tesis hemos abordado el estudio de las relaciones de causalidad entre la desigualdad de la renta, la pobreza monetaria y el crecimiento económico aportando una nueva perspectiva que pretende salvar gran parte de las limitaciones anteriormente mencionadas. En primer lugar, el enfoque metodológico adoptado toma como punto de partida los avances producidos en la computación de indicadores sintéticos a partir de modelos VAR multivariantes para datos de panel y los combina a su vez con las aportaciones de la literatura de mapas causales y modelos gráficos. Otro aspecto a destacar es que se posibilita el aumento del número de variables endógenas incluidas en el análisis, manteniendo bajo control el coste computacional asociado. Esto nos permite aumentar el número de variables distributivas incluidas en nuestro análisis, teniendo en cuenta tanto la desigualdad como la pobreza de forma simultánea y plantear escenarios más complejos. De esta forma, se trata de capturar la causalidad en términos dinámicos, explorando todos los flujos de causalidad potenciales que puedan existir entre los tres fenómenos, sin tratar de imponer a priori, de forma exógena, un determinado sentido en la relación.

Objeto de estudio

El ámbito de estudio de esta tesis han sido las economías europeas: los 26 estados miembros de la UE -excluyendo Serbia, por la escasa longitud temporal de sus datos-, además de Reino Unido, Islandia, Suiza y Noruega. Esto resulta interesante por varias razones: para empezar, el grupo de economías elegidas presenta un mayor grado de homogeneidad que el que de estudios anteriores. Si bien es cierto que el nivel de desarrollo de estos países puede diferir, también lo es que, debido a la arquitectura institucional de la UE, ha podido producirse un proceso de convergencia que haya permitido reducir esas diferencias. Asimismo, y en referencia a la arquitectura institucional europea, desde los orígenes de esta, han existido referencias a la consecución de determinados objetivos sociales, lo que ha promovido la creación y fortalecimiento de sus Estados del bienestar. En este sentido, pensamos que resulta fundamental conocer las dinámicas internas que se están produciendo entre los fenómenos señalados para evaluar el grado de consecución efectiva de dichos objetivos. Por otra parte, también resulta interesante valorar si la existencia de tales objetivos influye en el surgimiento de un patrón común entre las variables de interés.

Por último, un potente catalizador de las relaciones entre crecimiento y variables distributivas, a veces no suficientemente advertido por la literatura, es el rol de los sistemas públicos de cobertura social (lo que se viene a llamar comúnmente "Estados de bienestar"). Estos tienen un papel fundamental en la reducción de la desigualdad con la que se distribuye la renta que los individuos reciben derivada de su actividad de mercado y, por tanto, en la mejora de las condiciones sociales y de vida de los ciudadanos menos favorecidos. Por esta razón, hemos considerado de interés estudiar las posibles similitudes y disparidades que pueden existir en los sistemas de prestaciones públicas e impuestos europeos. Asimismo, alineada con la vocación dinámica de nuestro análisis, también se ha considerado fundamental capturar cómo han evolucionado las distintas similitudes observadas durante el periodo. Para ello, esta tesis ha puesto el foco de atención en la distribución que los distintos sistemas públicos hacen de las prestaciones y los impuestos, la forma concreta en la que se materializan y la efectividad demostrada en cuanto a la consecución de los objetivos sociales de reducción de la pobreza y desigualdad. A partir de estas similitudes, se ha propuesto una clasificación de los sistemas europeos que, de forma simultánea, ha permitido expandir el análisis global inicial de las relaciones causales. De esta forma es posible introducir las similitudes entre los sistemas público como elemento de agrupación de los países europeos y estudiar así su papel en la explicación de la heterogeneidad de patrones dinámicos de causalidad observados en el análisis global.

El periodo de análisis abarca, como se dijo al inicio de esta introducción, los años transcurridos entre el 2003 y el 2019. Este periodo resulta particularmente interesante por diversas razones. Para empezar, a lo largo del periodo se producen diversos eventos que provocan varias inflexiones del ciclo económico. En este sentido, contamos con los años de crecimiento previos a la Gran

Recesión, la crisis financiera y la económica derivada de esta; los años de crisis de deuda soberana y el periodo de austeridad asociado con las políticas de consolidación fiscal seguidas, y, por último, los años de la recuperación. Asimismo, durante el periodo y, sobre todo, a raíz de la crisis financiera se producen transformaciones importantes en los sistemas institucionales en gran parte de los países de la Unión Europea. Estas transformaciones han podido tener un impacto significativo en la configuración de la dinámica causal entre las variables. Por último, también asistimos, durante el periodo de recuperación, a un estancamiento de los indicadores distributivos, que no parecieron mejorar al ritmo que los hacía la economía.

Quizá, debido a la mejora en la mayor parte de los indicadores sociales acontecida en una parte de los países europeos tras la Segunda Guerra Mundial vinculada al desarrollo y fortalecimiento de los diferentes sistemas de estado de bienestar supuso la asunción acrítica de que los procesos de crecimiento económicos de dichas economías iban a depender de factores estructurales que, además, supondrían automáticamente una mejora económica y de calidad de vida para el conjunto de la sociedad, lo que en cierto modo coincidía con la hipótesis planteada en el trabajo seminal de Kuznets (1955).

Sin embargo, la evolución que han experimentado gran parte de los indicadores sociales y distributivos en las últimas décadas abre la puerta a cuestionarse la validez de estos planteamientos. En la mayor parte de las economías avanzadas ha tenido lugar desde los años 80 un incremento sostenido de la desigualdad, alcanzando en algunos casos sus máximos históricos. Parte de este incremento de la desigualdad puede explicarse por la dinámica que se ha producido en la parte más alta de la distribución de la renta. Así, numerosos estudios han constatado como el 1% más rico de la población ha visto incrementados sus ingresos en una proporción considerablemente superior a la que lo han hecho los ingresos de la parte media-baja de la distribución (OECD, 2015; Atkinson, 2015; Chancel, 2021). No obstante, la evolución de la desigualdad en la renta personal no pude explicarse únicamente por lo ocurrido en la parte alta de la distribución. Al contrario, se han producido además una serie de cambios estructurales que han reforzado esta tendencia. Entre otros, cabe señalar los procesos de transformación que se han producido en los diferentes mercados de trabajo, los efectos de la globalización y de la automatización/digitalización.

Una tendencia que podría hacerse extensiva a la pobreza, pues la evolución experimentada por este fenómeno presenta similitudes con la desigualdad. A nivel general, en gran parte de las economías desarrolladas ha podido observarse un empeoramiento en el desempeño de gran parte de los indicadores de pobreza. Del mismo modo, han podido constatarse nuevos fenómenos como los trabajadores pobres *(in-work poverty),* la carencia material (severa o no) así como la pobreza de larga duración y la pobreza en su manifestación más intensa, ya cronificada. Todo esto, de

nuevo, nos invita a reflexionar sobre la validez de presuponer en el diseño de políticas públicas una relación automática entre el crecimiento económico y las mejoras de la calidad de vida.

Cuestiones metodológicas

Para abordar los objetivos planteados en la tesis se ha optado por adoptar un enfoque metodológico general basado en la información presente en los datos -*data driven approach*-. De esta forma, se ha pretendido evaluar distintas aportaciones de la teoría económica aprovechando los avances técnicos, computacionales y en la recopilación de datos que se han producido en los últimos años.

En la primera parte de la tesis se ha planteado una propuesta metodológica que permite analizar relaciones de causalidad sin imponer una estructura causal previa. A su vez, esta propuesta se ha complementado con la aplicación de algoritmos de búsqueda causal que suponen una herramienta eficaz a la hora de establecer el orden causal entre distintos fenómenos. Asimismo, como resultado adicional derivado de este bloque se ha producido un toolbox de Matlab que permite aplicar la propuesta metodológica a otros análisis futuros.

En la segunda parte de la tesis, y continuando con la vocación del enfoque general adoptado, para llevar a cabo la clasificación de las economías europeas, también se opta por utilizar técnicas de *machine learning* no supervisado. Sin ser objetivo de esta tesis profundizar en estas técnicas, el resultado obtenido ha servido como criterio neutral para ampliar el análisis de las relaciones causales para las economías europeas.

Todos los indicadores utilizados para los distintos análisis de esta tesis se han calculado a partir de los microdatos de la EU Statistics on Income and Living Conditions (EUSILC). Además, para el Capítulo 3, se ha utilizado también la herramienta EUROMOD, el modelo de microsimulación de los sistemas de prestaciones e impuestos, auspiciado por la Comisión Europea.

Capítulo 1

En este artículo, proponemos un nuevo enfoque para analizar la causalidad de Granger en un entorno de datos de panel multivariantes, así como para identificar una "senda de causalidad" definitiva que excluya relaciones redundantes. Concretamente, combinamos los recientes avances que se han desarrollado basados en técnicas de metaanálisis para estimar la causalidad de Granger en paneles mixtos heterogéneos (Emirmahmutoglu y Kose, 2011; Dumitrescu y Hurlin, 2012) con modelos gráficos (DAGs) (Spirtes et al., 2000; Demiralp y Hoover, 2003; Eichler, 2007, 2012) que buscan de manera iterativa relaciones de dependencia -causalidad- en un conjunto complejo de información multivariante.

Completemos nuestra propuesta con dos ilustraciones diferentes. La primera revisita estudios existentes en el contexto de modelos de Vector Autorregresivo (VAR) para datos de panel

aplicados al análisis de la prevalencia de la llamada Curva de Phillips (el nexo precios-desempleo) durante el periodo de la Unión Económica y Monetaria (UEM) para una selección de países europeos (zona euro 12). Para ello, nuestros resultados confirman la prevalencia de hallazgos no significativos al respecto para todo el panel y, adicionalmente, para un subconjunto significativo de países (Europa Central y Periférica). Esto se revela porque nuestro enfoque va más allá de modelos reducidos y considera simultáneamente un número ampliado de variables, lo que elimina nexos redundantes. También identificamos las variables que lideran la dinámica subyacente para todo el panel (PIB, inflación y tasa de desempleo). A nivel nacional, solo cuatro países (Grecia, Finlandia, Italia y Luxemburgo) mantienen parcialmente una relación significativa -inversa- entre la inflación y la tasa de desempleo, pero no bidireccional. Finalmente, también encontramos un alto grado de heterogeneidad en términos de dinámica subyacente, lo que indica que pueden ser necesarias políticas específicas para cada país para tener en cuenta el nexo encontrado.

La segunda ilustración tiene como objetivo analizar las relaciones dinámicas entre precios, salarios y consumo privado para una muestra de los 12 miembros iniciales de la UEM durante el período 1999-2019. Los resultados obtenidos muestran una relación causal de los precios hacia los salarios, lo que podría apoyar la hipótesis de indexación salarial para el común de la muestra. Por el contrario, no encontramos evidencia de que los salarios causen un aumento de los precios, lo que nos permite descartar de forma generalizada la hipótesis de inflación salarial. Adicionalmente, el enfoque que adoptamos permite llevar a cabo análisis individuales de países, los cuales son esenciales para comprender las particularidades de cada economía. En este sentido, obtenemos que Irlanda es el único país donde el consumo privado parece ejercer presión sobre los precios. Mientras tanto, las economías mediterráneas como España y Grecia parecen seguir un modelo impulsado por la deuda, donde el consumo privado impulsa los niveles salariales.

Capítulo 2

El trabajo de este segundo Capítulo analiza las relaciones dinámicas entre desigualdad de ingresos, la pobreza monetaria y el crecimiento económico para una muestra de 30 economías europeas durante el periodo 2003-2019. Para ello, adoptamos un enfoque novedoso basado en un análisis dinámico que considera la variabilidad que puede producirse en la evolución de estas relaciones a lo largo del periodo analizado. El modelo panel-VAR propuesto nos permite realizar un análisis de causalidad de Granger entre las variables mencionadas. En una segunda etapa, completamos este análisis con la aplicación del algoritmo iterativo PC que nos permite interpretar los resultados del modelo mediante la definición de los correspondientes gráficos causales. Para el análisis empírico utilizamos microdatos de la base de datos EU-SILC para el periodo 2003-2019. Los resultados obtenidos muestran que, para el conjunto de países analizados, el crecimiento económico tiene un efecto positivo sobre la pobreza de ingresos. Al mismo tiempo, encontramos que la desigualdad causa un incremento de la pobreza. No obstante, encontramos

que esta relación se invierte. Es decir, incrementos de la pobreza, a su vez, también causan incrementos en la desigualdad, lo que se traduce en una relación de doble causalidad positiva entre ambas variables. Estos resultados irían en línea con la literatura *pro-ricos*. Finalmente, no encontramos pruebas de que el crecimiento económico tenga un efecto reductor de la pobreza o la desigualdad. Sin embargo, constatamos que estos resultados difieren entre países, mostrando una gran heterogeneidad respecto de los distintos sistemas públicos de prestaciones e impuestos.

Capítulo 3

El objetivo de del trabajo contenido en el tercer Capítulo es revisar algunas de las taxonomías de los Estados de Bienestar habitualmente consideradas en la literatura adoptando para ello un enfoque basado en datos (*data driven*). Particularmente influyente en este campo es la tipología de Estados de Bienestar propuesta por Esping-Andersen (1990), que ha servido de base a numerosos trabajos. Para llevar a cabo el objetivo del artículo, recopilamos una lista exhaustiva de indicadores de bienestar calculados a partir de EUROMOD, concretamente los que se utilizan habitualmente en la bibliografía relacionada. A continuación, aplicamos técnicas de agrupación o clúster *de machine learning no supervisadas* para determinar el número de grupos encontrados y los países pertenecientes a cada grupo. Asimismo, se ha reducido el problema de la dimensionalidad de los datos aplicando técnicas de Análisis de Componentes Principales (ACP) para evitar la inclusión de información redundante en el modelo. Una vez extraídas las tendencias subyacentes, se aplican técnicas no supervisadas de *clustering* para obtener clasificaciones alternativas de Estados de Bienestar. En este sentido, la contribución de este Capítulo es doble. En primer lugar, ampliamos la perspectiva desde la que se cuantifica el Estado de bienestar al incluir indicadores que engloban simultáneamente todas sus características fundamentales. En particular, siguiendo estudios previos, hemos seleccionado indicadores para cuantificar el grado de redistribución, la progresividad de los sistemas de prestaciones e impuestos, el peso relativo de cada instrumento, o la reducción de la pobreza alcanzada. En segundo lugar, obtenemos por pares de países la probabilidad de pertenecer al mismo clúster/grupo, en función del conjunto de características incluidas. Por último, formamos los grupos para aquellos países que superen el umbral de probabilidad del 65%.

Capítulo 4

Este Capítulo analiza las relaciones dinámicas entre la desigualdad de ingresos, la pobreza monetaria y el crecimiento económico para una muestra de diferentes estados de bienestar europeos durante el período 2003-2019. Para ello, se ha utilizado la clasificación novedosa propuesta en el Capítulo 3, que clasifica a los países según la distribución de sus recursos. Esta clasificación propone 7 clústeres diferentes de estados de bienestar. A continuación, se realiza un análisis causal de Granger para el período 2003-2019 para cada clúster. El enfoque econométrico se basa en el trabajo de Dumitrescu y Hurlin (2012) y Emirmahmutoglu y Kose (2011), quienes

proponen una aproximación para calcular estimadores de datos en panel basados en la información individual de distintas unidades transversales (países) que conforman cada subgrupo. Nuestros resultados muestran que existe un alto grado de heterogeneidad en cuanto a las relaciones, dependiendo del grupo de países que examinemos. Sin embargo, también es posible encontrar ciertos rasgos o regularidades que se repiten con relativa frecuencia. Tal vez lo más llamativo sea que solo en uno de los grupos encontramos una relación directa significativa entre la desigualdad y el crecimiento económico. En cambio, la relación (directa) entre crecimiento económico y pobreza es significativa en 5 de los 7 grupos analizados, por lo que parece significativamente más robusta. En 3 de los 5 grupos analizados, el crecimiento no solo no reduce la pobreza, sino que la aumenta. En estos grupos de economías, parece estar ocurriendo un crecimiento económico pro-rico. Asimismo, en 2 de los 5, la pobreza precede al crecimiento económico, lo que estaría en línea con la hipótesis de la eficiencia.

Introduction

This Thesis focuses on studying the causal relationship in dynamic terms that occurs between the phenomena of inequality, poverty and economic growth for a series of European economies during the period 2003-2019. This period is marked by profound macroeconomic changes, from the years of sustained economic growth prior to the Great Recession experienced by many economies, to the abrupt interruption of this growth path due to the effects of the economic crisis, the Sovereign Debt Crisis that affected some peripheral economies, the impact of subsequent austerity policies, and the subsequent recovery period.

For this purpose, the Thesis has been structured in two fundamental blocks. The first, methodological in nature, focuses on proposing a new approach to analyse causal relationships in panel data environments through VAR models. Since this first block is of transversal nature, it has been complemented with two macroeconomic illustrations, which, although somewhat distant from the main topic of analysis of the Thesis, it serves to illustrate the advantages that this approach can provide in analytical terms.

The second block applies the proposed methodological approach to the main subject of this Thesis: the dynamic causal relationships among income inequality, monetary poverty, and economic growth in European economies. To this end, the second chapter focuses on all European economies, aiming to analyse whether a common pattern of causality can be found among them. Chapters three and four, however, delve into potential differences within this pattern, linking these variations to distinct types of welfare and tax systems. For this purpose, the third chapter is devoted to proposing a new classification of European countries based on the similarities between their benefit and tax systems and, more specifically, on how these are distributed across the population. The fourth chapter then replicates the analysis conducted in Chapter 2, independently for each one of the different groups identified in Chapter 3.

Although there is a clear continuity between the blocks and chapters that make up the Thesis, there is also a vocation of independence between each of the chapters, so that it has been intended to be possible each to be understood separately. This is why some of the content is repeated in some sections of the Thesis.

Literature on the relationship between economic growth, inequality, and poverty.

One of the economic research topics that has raised the most interest in recent years is the nature of the relationship between economic growth and various distributive variables -with inequality being the phenomenon that has attracted the most attention-. In this regard, the academic debate has primarily followed two approaches. On the one hand, part of the effort has been directed either toward developing various theoretical models to capture the macroeconomic effects arising from inequality or toward modelling the distributive consequences generated by different growth

models. On the other hand, the literature offers numerous empirical studies that have devoted part of the research effort to test the validity of these models in different economies and at different points in time.

In the theoretical field, the contributions of different authors have proposed both models that predict a positive effect of inequality on economic growth, fostering it, and models that predict the opposite effect, in which inequality has a negative effect on economic growth. Among the former, the fundamental transmission mechanisms are the incentives perceived by agents which, either through an increase in effort or through a more efficient allocation of resources, provide incentives for growth (*Incentive Hypothesis*). In contrast, theoretical works asserting that inequality has negative effects on economic growth point primarily to social conflict, political instability, and the underutilization of human capital potential as the main transmission mechanisms (Opportunities Hypothesis).

As for empirical contributions, one of the foundational contributions that initiates a long tradition of studies is the seminal work of Kuznets (1955). In this study, the author observed a quadratic relationship between inequality and economic growth, which has come to be known as the Kuznets Curve, differentiating according to the stage of development in which the countries were found, concluding that if higher levels of inequality were a common characteristic of economies in initial stages of development, this tendency turned into the opposite sign once the economies moved to more advanced stages of development. Subsequently, different modifications to this hypothesis have been developed, among which the pro-poor growth literature stands out. The main contribution of this literature consisted in proposing models in which the relationship was considered from the perspective of economic growth. If economic growth reduced inequality, it was established that the process of economic development should lead to a reduction in *poverty -pro-poor growth-*. If, on the contrary, inequality increased, this favoured an increase in poverty -*pro-rich growth-*.

Since these seminal works, numerous analyses have followed in an attempt to test the validity of these hypotheses. However, part of the development of this branch of empirical literature has been profoundly conditioned by the availability of data. Consequently, it was not until the 1990s that studies began to emerge focusing on a sufficiently broad group of economies. Initially, given the inconsistency of the time series, most analyses applied cross-section econometric techniques adopting a comparative statics approach. Alesina and Rodrick (1994) select a total of between 46 and 70 economies between 1960 and 1958; Persson and Tabellini (1994) focus on 56 economies also between 1965 and 1980; Clarke (1955) carries out his exercise for a large number of countries (between 74 and 81), for the 1970s and 1980s, depending on data availability. Deininger and Squire (1998), in turn, propose their own database covering a broad period (1960-1992) that

includes information on a high number of countries (between 68 and 80). Castelló-Climent and Doménech (2002) expand the number of countries to between 67 and 83 for the years 1960 to 1990. Knowles (2005), for the same period, includes a total of 40 economies. While a complete consensus is not reached, the majority of these studies conclude that the effect of inequality on economic growth is negative.

From the 2000s onwards, as the compilation and consistency of data collection improved, studies increasingly began to adopt econometric techniques for panel data across various intervals of multi-year averages. Deininger and Olinto (2000) include between 31 and 60 economies at different points within the 1966–1990 period. Forbes (2000) focuses on analysing the relationship for 45 different economies between 1965 and 1995. Barro (2000) conducts his study over the same period, analysing 84 countries. Banerjee and Duflo (2003) examine 45 countries between 1960 and 1990. Voitchovsky (2005) focus on 21 developed countries during the 1975–2000 period. Castelló-Climent (2010) includes a total of between 56 and 102 countries during the period from 1960 to 2000. Ostry, Berg, and Tsangarides (2014) focus on the period 1960–2010, analysing a total of 90 economies, while Halter, Oechslin, and Zweimüller (2014) analyse the same number of economies for the period 1966–2005.

Most of these studies use System-GMM type estimators, although fixed and random effects models are also frequently employed. However, despite the extensive academic work dedicated to analysing the same or closely related periods, their results have not led to a conclusive consensus on the nature of the phenomenon, as both positive and negative effects have been found.

Finally, although less numerous, some analyses have also emerged that are closer to the approach followed in this doctoral thesis. Specifically, those that question which variable takes the lead in the significant dependency relationship that may be identified. For this reason, we believe that a methodological alternative to resolve the indeterminacy of this relationship is to analyse it in terms of Granger causality. Thus, Atems and Jones (2015) propose a bivariate VAR model for the different states of the United States, examining the potential bidirectional causality between inequality and economic growth. In turn, Grigoli, Paredes and Di Bella (2016) analyse the possible endogeneity between both phenomena for a sample of 70 countries over a 20-year period, taking into account both temporal variability and cross-country heterogeneity. Brida, Carrera and Segarra (2020) carry out a dynamic Granger causality analysis but using non-parametric techniques that allow to classify the 38 countries in their study into distinct clusters.

Likewise, there is a substantial body of empirical work aimed at quantifying the impact of economic growth on poverty reduction, usually based on elasticity calculations. In this way, a link is established between the growth of the lowest incomes in an economy and average income

growth. In general, the consensus in this branch of the literature is much greater than that found in empirical studies on inequality, and a positive effect of economic growth on poverty reduction ("pro-poor growth") is commonly found (Dollar and Kraay, 2002; Dollar et al., 2016). However, by the construction of the approach itself, nothing can be said about how poverty affects growth. For their part, Adams (2004) and Ravallion and Chen (1997) estimate the growth-poverty elasticity for a selection of developing countries, obtaining an impact range of between 2% and 3%. Others try to explain the different magnitudes of the effect by looking at the type of growth, mainly through sectoral composition, or by examining the initial economic conditions. Among others, Loayza and Raddatz (2010) analyse the effect of economic growth on poverty reduction at various levels of disaggregation of production for a group of developing countries. Ferreira et al. (2010) perform a similar exercise, focusing on Brazil. Mussida and Sciulli (2022) analyze the dynamics of poverty at different points in the economic cycle -pre and post crisis- for a number of European countries.

Despite the prolific nature of this literature, many of these studies share common features that can help to explain the diversity of their results and that, in addition, underpin many of the decisions made in this doctoral thesis. Starting with the economic scope, most of these studies have focused either on developing economies or, on the contrary, on a broad sample of countries with heterogeneous economic structures. In contrast, although it may seem somewhat, striking, studies that have focused exclusively on developed economies and 'rich' countries are not as numerous, nor are those directed at countries that share a political-economic structure, as is the case of the Member States of the European Union.

On the other hand, as shown in the aforementioned works, the vast majority of studies focus only on one of the two distributive dimensions considered and its relationship with economic growth. However, we believe that both poverty and inequality are phenomena that may be closely related, with one having an effect on the other, particularly when certain imbalances become chronic in the medium or long term.

Likewise, another common aspect in this branch of the literature has been the predominantly comparative static approach, somewhat neglecting the dynamic structure. It is precisely these dynamics that we intend to capture in the paper through the use of Granger causality techniques. Thus, even in cases where panel data structures have been employed, most of the papers have tended to opt for averaging various years and comparing these averages.

Finally, although it may be considered a somewhat minor issue, another possible factor often pointed out as responsible for the heterogeneity of results in this type of studies is related to the various data sources from which different indicators of inequality or poverty are calculated. These sources often differ in terms of coverage, observational unit, or the definition of income used.

In this regard, and given that the debate remains open in academic, institutional, and social forums, in this thesis we have addressed the study of the causal relationships between income inequality, monetary poverty and economic growth, providing a new perspective that aims to overcome many of the aforementioned limitations. Firstly, the methodological approach adopted takes as a starting point the advances in the computation of synthetic indicators on the basis of multivariate VAR models for panel data and combines them with contributions from the literature on causal maps and graphical models. Another noteworthy aspect is that it allows for an increase in the number of endogenous variables included in the analysis while keeping the associated computational cost under control. This enables us to expand the number of distributive variables included in our analysis, considering both inequality and poverty simultaneously, and to propose more complex scenarios. In this way, the objective is to capture causality in dynamic terms, exploring all the potential causal flows that may exist between the three phenomena, without trying to impose a priori, in an exogenous way, a specific direction in the relationship.

Subject of study

The scope of study of this thesis has been the European economies: the 26 EU member states -excluding Serbia, due to the limited time span of its data-, as well as the United Kingdom, Iceland, Switzerland and Norway. This is interesting for several reasons: firstly, the selected group of economies presents a greater degree of homogeneity than in previous studies. While it is true that the level of development of these countries may differ, it is also true that, due to the institutional architecture of the EU, a process of convergence may have taken place that has reduced these differences. Likewise, and in reference to the European institutional architecture, since its origins, there have been references to the achievement of certain social objectives, which has promoted the creation and strengthening of its welfare states. In this sense, we believe it is essential to understand the internal dynamics occurring among the highlighted phenomena in order to evaluate the degree of effective achievement of these objectives. On the other hand, it is also interesting to assess whether the existence of such objectives influences the emergence of a common pattern among the variables of interest.

Finally, a powerful catalyst of the relationships between growth and distributive variables, sometimes not sufficiently noted in the literature, is the role of public social coverage systems (commonly referred to as “welfare states”). These systems play a fundamental role in reducing the inequality with which income derived from market activities is distributed among individuals and, therefore, in improving the social conditions and living standards of the less advantaged citizens. For this reason, we have considered it of interest to study the possible similarities and disparities that may exist in the European public tax- benefits systems. Additionally, aligned with the dynamic nature of our analysis, it has also been considered essential to capture how the different similarities observed during the period have evolved. To this end, this thesis has focused

on the distribution that the different public systems make of benefits and taxes, the concrete form in which they are materialized and the effectiveness demonstrated in terms of achieving the social objectives of reducing poverty and inequality. Based on these similarities, a classification of European systems has been proposed, which has simultaneously allowed for an expansion of the initial global analysis of causal relationships. In this way, it is possible to introduce the similarities among public systems as a means of grouping European countries and thus examine their role in explaining the heterogeneity of dynamic patterns of causality observed in the global analysis.

The period of analysis covers, as mentioned at the beginning of this introduction, the years between 2003 and 2019. This period is particularly interesting for several reasons. To begin with, several events occur throughout the period that trigger various inflections of the economic cycle. In this regard, we have the years of growth prior to the Great Recession, the financial crisis and the economic crisis derived from it; the years of the sovereign debt crisis and the period of austerity associated with the fiscal consolidation policies followed; and, finally, the years of recovery. In addition, during this period and, especially, in the wake of the financial crisis, major transformations took place in the institutional systems of most of the countries of the European Union. These transformations may have had a significant impact on the configuration of the causal dynamics among the variables. Finally, during the recovery period, we also observed a stagnation of the distributive indicators, which did not seem to improve at the same pace as the economy.

Perhaps, due to the improvement in most social indicators that occurred in some European countries after World War II, linked to the development and strengthening of the different welfare state systems, there was an uncritical assumption that the economic growth processes of these economies would depend on structural factors that would automatically lead to an economic and quality of life improvement for society as a whole. This somewhat aligned with the hypothesis presented in Kuznets's (1955) seminal work.

However, the evolution experienced by many social and distributive indicators in recent decades raises questions about the validity of these assumptions. In most advanced economies there has been a sustained increase in inequality since the 1980s, reaching historic highs in some cases. Part of this increase in inequality can be explained by the dynamics that have occurred at the top of the income distribution. Thus, numerous studies have found that the richest 1% of the population has seen their incomes increase at a considerably higher rate than those of the middle and lower parts of the distribution (OECD, 2015; Atkinson, 2015; Chancel, 2021). Nevertheless, the evolution of inequality in personal income cannot be explained exclusively by what has happened in the upper part of the distribution. On the contrary, a series of structural changes have also reinforced this trend. Notably, these include the transformation processes that have taken place in the different labour markets, the effects of globalization and automation/digitization. This trend

could be extended to poverty, since the evolution experienced by this phenomenon shows similarities with inequality. Generally speaking, in many developed economies there has been a deterioration in the performance of a large number of poverty indicators. Similarly, it has been identified new phenomena such as in-work poverty, material deprivation (severe or non-severe), as well as long-term poverty and poverty in its most intense manifestation, chronic poverty. All this, once again, invites us to reflect on the validity of presupposing in the design of public policies an automatic relationship between economic growth and improvements in the quality of life.

Methodological issues

In order to address the objectives set forth in the thesis, a general methodological approach based on the information present in the data -data driven approach- has been adopted. In this way, the aim has been to evaluate different contributions from economic theory, taking advantage of the technical, computational and data collection advances that have occurred in recent years.

In the first part of the thesis, a methodological proposal that allows the analysis of causal relationships without imposing a prior causal structure has been presented. This proposal has been further complemented with the application of *causal search* algorithms, which provide an effective tool for establishing the causal order among different phenomena. Additionally, as a supplementary result derived from this section, a MATLAB toolbox has been developed to facilitate the application of the methodological proposal to future analyses.

In the second part of the thesis and continuing with the vocation of the general approach adopted, in order to carry out the classification of the European economies, unsupervised machine learning techniques are also used. Although it is not the aim of this thesis to go deeper into these techniques, the result obtained has served as a neutral criterion to extend the analysis of the causal relationships for the European economies.

All the indicators used for the different analyses in this thesis have been calculated from the EU Statistics on Income and Living Conditions (EUSILC) microdata. In addition, for Chapter 3, the EUROMOD tool, the microsimulation model of the tax-benefit systems, developed by the European Commission, has also been used.

Chapter 1

In this paper, we propose a new approach for testing Granger causality in a multivariate panel data environment, as well as for identifying one ultimate "causality path" excluding any redundant relationships. For the sake of concreteness, we combine recent developments introduced to estimate Granger causality procedure based on meta-analysis in heterogeneous mixed panels (Emirmahmutoglu and Kose, 2011; Dumitrescu and Hurlin, 2012) with graphical models (DAGs) proposed in the expanding strand of literature (Spirtes *et al*, 2000; Demiralp and Hoover, 2003; Eichler, 2007, 2012) that iteratively searches for dependencies within a multivariate information

set. We illustrate our proposal by revisiting existing studies in the context of panel Vector Autoregressive (VAR) models. The first illustration is applied to the analysis of the prevalence of the so-called Phillips Curve (the prices-unemployment nexus) in the context of the Economic and Monetary Union (EMU) period for a selection of European Countries (euro area 12). For this purpose, our results confirm the prevalence of non-significant findings in this regard for the whole panel and, additionally, for meaningful subset of countries (central European and Peripherical). This is uncovered because our approach goes beyond reduced models and consider simultaneously an expanded number of variables which eliminates redundant nexus. We also identify the variable leading the underlying dynamic for the whole panel (GDP, inflation and unemployment rate). At national level, only four countries (Greece, Finland, Italy, and Luxembourg) partially hold a significant -inverse- relationship between inflation and unemployment rate, but not bidirectional. Finally, we also find a high degree of heterogeneity in terms of underlying dynamic indicating that country-specific policies may be needed to account for the found nexus. The second illustration is devoted to analysing the dynamic relationships between prices, wages and private consumption for a sample of the 12 initial EMU members for the period 1999-2019. The results obtained reveal a causal relationship from prices to wages, supporting the wage indexation hypothesis for the whole sample. On the contrary, we do not find evidence of wages causing any increase of prices, which enables us to disregard the wage-inflation hypothesis. Additionally, the approach adopted enables country-specific analyses, which are essential for understanding the specificities of each economy. In this regard, we find that Ireland is the only country where private consumption appears to exert pressure on prices. Meanwhile, Mediterranean economies like Spain and Greece seem to follow a debt-led model where private consumption drives wage levels.

Chapter 2

This paper analyses the dynamic relationships between income inequality, monetary poverty and economic growth for a sample of 30 European economies over the period 2003-2019. To do so, we adopt a novel approach based on a dynamic analysis that considers the variability that can occur in the evolution of these relationships over the period analysed. The proposed panel-VAR model allows us to perform a Granger causality analysis between the variables mentioned. In a second stage, we complete this analysis with application of the iterative PC algorithm that allows us to interpret the results of the model by defining the corresponding causal graphs. For the empirical analysis we use micro-data from the EU-SILC database for the period 2003-2019. The results obtained show that, for the set of countries analysed, economic growth has a positive effect on income poverty. At the same time, we found inequality has a positive effect on poverty. We also find that this dynamic is reversed, with a double positive causality between these variables, which goes in line with pro-rich literature. In addition, we do not find evidence of a poverty- or

inequality- reducing effect of economic growth. However, we find that these results differ across countries, showing great heterogeneity between different tax-benefit systems.

Chapter 3

The aim of this paper is to revisit some of the well-established Welfare State taxonomies adopting a data-driven approach. Particularly important in the field is the typology of Welfare States proposed by Esping-Andersen (1990), which has served as a basis to numerous works. To fulfil the aim of the paper, we compile a comprehensive list of EUROMOD welfare indicators, specifically those being commonly used in the related literature. Then, we applied machine-learning unsupervised cluster techniques to determine the number of groups found and the countries belonging to each group. Previously, when needed, we reduce the dimensionality problem by applying Principal Components Analysis (PCA) techniques to prevent the inclusion of redundant information in the model. Once we have extracted the subjacent trends, unsupervised techniques of clustering are applied to obtain alternatives classifications of Welfare States. In this regard, the contribution of this paper is twofold. First, we broaden the perspective from which Welfare State is quantified by including indicators that encompass simultaneously all its fundamental features. Particularly, following the previous studies, we have selected indicators to quantify the degree of redistribution, the progressivity of the tax-benefit systems, the relative weight of each instrument, the poverty reduction achieved. Second, we obtain for each pair of countries the likelihood of belonging to the same cluster/group, depending on the set of features included.

Chapter 4

This paper analyses the dynamic relationships between income inequality, monetary poverty and economic growth for a sample of different European Welfare states over the period 2003-2019. To do so, we have used a novel classification proposed in Chapter 3, which classify the countries according to the distribution of its resources. This classification proposes 7 different clusters of welfare states. Then, a Granger causal analysis for the period 2003-2019 is performed for each cluster. The econometric approach relies on the work of Dumitrescu and Hurlin (2012) and Emirmahmutoglu and Kose (2011) who proposed a strategy to compute panel data estimators based on the individual information of the cross-sectional units -countries- conforming each subgroup. Our results show that there is a high degree of heterogeneity in terms of relationships depending on the cluster of countries we examine. Despite this, it is also possible to find certain features or regularities that are repeated with a certain frequency. Perhaps most striking is that only in one of the groups is there a direct relationship between inequality and economic growth. In contrast, the direct relationship between economic growth and poverty is significant in 5 of the 7 groups analysed. In 3 of the 5 groups analysed, growth not only does not reduce poverty, but increases it. In these groups of economies, pro-rich economic growth seems to be occurring.

Likewise, in 2 of the 5, poverty precedes economic growth, which would be in line with the efficiency thesis.

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Chapter 1

Graphical modelling of multivariate panel data models. Two applications for the prevalence of Phillips Curve in the EMU period and the nexus of wages, prices and private consumption.

Abstract

In this paper, we propose a new approach for testing Granger causality in a multivariate panel data environment, as well as for identifying one ultimate "causality path" excluding any redundant relationships. For the sake of concreteness, we combine recent developments introduced to estimate Granger causality procedure based on meta-analysis in heterogeneous mixed panels (Emirmahmutoglu and Kose, 2011; Dumitrescu and Hurlin, 2012) with graphical models (DAGs) proposed in the expanding strand of literature (Spirtes *et al*, 2000; Demiralp and Hoover, 2003; Eichler, 2007, 2012) that iteratively searches for dependencies within a multivariate information set. We illustrate our proposal by revisiting existing studies in the context of panel Vector Autoregressive (VAR) models. The first illustration is applied to the analysis of the prevalence of the so-called Phillips Curve (the prices-unemployment nexus) in the context of the Economic and Monetary Union (EMU) period for a selection of European Countries (euro area 12). For this purpose, our results confirm the prevalence of non-significant findings in this regard for the whole panel and, additionally, for meaningful subset of countries (central European and Peripherical). This is uncovered because our approach goes beyond reduced models and consider simultaneously an expanded number of variables which eliminates redundant nexus. We also identify the variable leading the underlying dynamic for the whole panel (GDP, inflation and unemployment rate). At national level, only four countries (Greece, Finland, Italy, and Luxembourg) partially hold a significant -inverse- relationship between inflation and unemployment rate, but not bidirectional. Finally, we also find a high degree of heterogeneity in terms of underlying dynamic indicating that country-specific policies may be needed to account for the found nexus. The second illustration is devoted to analysing the dynamic relationships between prices, wages and private consumption for a sample of the 12 initial EMU members for the period 1999-2019. The results obtained reveal a causal relationship from prices to wages, supporting the wage indexation hypothesis for the whole sample. On the contrary, we do not find evidence of wages causing any increase of prices, which enables us to disregard the wage-inflation hypothesis. Additionally, the approach adopted enables country-specific analyses, which are essential for understanding the specificities of each economy. In this regard, we find that Ireland is the only country where private consumption appears to exert pressure on prices. Meanwhile, Mediterranean economies like Spain and Greece seem to follow a debt-led model where private consumption drives wage levels.

1. Motivation

Starting from Granger (1969), the notion of Granger causality has been widely applied across the field of econometrics. The simplicity, adaptability, and transversality of this concept – based on the idea that a cause (variable X) contains 'early' information about an effect (variable Y) that is unique and present in no other variable (Granger, 2003) – are among the most determinant justifications for so extraordinary a compilation of academic citations.

Due to computational limitations, a great share of these applications has been limited to the analysis of potential causality between pairs of variables. However, expanding the conceptual framework to complex information systems appears to be a necessary task for the accurate identification of existing patterns of causality. In particular, the context of Vector Autoregressive (VAR) models has proven very suitable for this approach as it intuitively classifies as endogenous or exogenous the different indicators included in analysis. The first of these classes may react to changes in other endogenous variables, while the second evolves without interactions with other variables. To be precise, when we identify a *cause*, our approach allows for testing of the *true* existence of a causal relationship by conditioning on (some of) the remaining endogenous variables which may play a role in defining the total impact of '*cause'* on '*effect'* – for instance, if a third variable is a common cause for both.

Meanwhile, graph-theoretic methods and the theory of causal discovering have been gaining popularity in the econometric literature. These methods make use of discovery algorithms[1] to find patterns of (in)dependence on the data. Among the main virtues is that these techniques eliminate the need to impose strict *a priori* assumptions such as a prior ordering of variables (Spirtes *et al,*, 2000). Although the techniques were originally conceived for non-temporal data, studies have recently been developed that adapt them to data with a temporal structure. In this regards, Demiralp and Hoover (2003) show that the PC algorithm can be an effective tool in selecting the contemporaneous causal orders of SVARs, and Eichler (2007, 2012) and Runge (2018) provide a framework that allows the use of path diagrams for inferring the dynamic causal relationship among different variables.

Testing for Granger causality in the literature of panel data econometrics has also increased in frequency as the availability of this sort of data has improved. The usual and basic method when the variables are stationary consists in analysing the significance of the block of lags, normally using a Wald test. In this way, the null hypothesis is formulated as 'zero restrictions in the coefficients'. However, due to diverse sources of heterogeneity, alternative methods have likewise been developed. In a first group of studies, the parameters of equations are constant

[1] These algorithms can reveal causal structures from purely or mostly observational data. For a practical guide, see Malinsky and Danks (2018).

across individuals, meaning that causality occurs either everywhere or nowhere in the panel; in another group, the parameters can vary (see Holtz-Eakin *et al,* 1988; Hurlin and Venet, 2001; Hurlin, 2004). The main drawback is to expect the same causal relationships will occur between all individuals. As Nair-Reichert and Weinhold (2001) suggest, it is possible that, in a heterogeneous panel treated as a homogeneous, the underlying causal relationships between individuals may be missing (see also Hansen and Rand, 2006). These authors instead consider a variation of the Mixed Fixed and Random (MFR) model.

The aim of this paper is to propose a new approach for testing Granger causality in panel data in the context of VAR models. Our proposal allows to easily extend the number of relevant variables (heretofore generally limited to two) to adapt the analysis to complex information systems. Very significantly, we propose an alternative procedure based on the averaging of individual Wald test statistics of cross-sectional units using Fisher's transformation framework. In this respect we follow Dumitrescu and Hurlin (2012) and Emirmahmutoglu and Kose (2011), who test causal relationships in panel data by transforming individual tests into a composite measure.[2]

In addition, as a novelty, we apply graph-theoretic methods for causal analysis in panel data models. We use the PC algorithm in its stable version to select the optimal causal ordering among all possible orderings. Another contribution of our work therefore involves the linking of two literatures that have until now evolved independently.

We illustrate the advantages and versatility of our proposal by revisiting existing studies in the context of panel Vector Autoregressive (VAR) models applied to two different although closely related topics. The first application refers to the analysis of the prevalence of the so-called Phillips Curve (the prices-unemployment nexus) in the context of the Economic and Monetary Union (EMU) period for a selection of European Countries (Euro Area 12). The second consists of a revisit of the nexus between prices, wages and private consumption, also for the 12 Euro Area countries for the period 1996-2020. Previously, such complex topics have been explored intensively in the literature from various perspectives. However, the evidence obtained is mixed and territory or period specific. In this regard, the multivariate approach proposed here allows the adoption -and comparison- of extended models which includes/excludes relevant variables, in order to fully understand their role in shaping the ultimate dynamic relationships. Consequently, our methodology enables a deeper understanding of the different transmission channels affecting the dynamic between the variables of interest in the medium/long term.

The paper is organized as follows. Section 2 sets out our methodology. Section 3 presents both empirical applications, and Section 4 provides some concluding remarks.

[2] Averaging individual tests in order to obtain a statistic for the whole sample has become a common practice in Units Roots framework. See Im *et al* (2003).

2. Methodological issues[3]

In this section, we present the methodology proposed for identifying the *true* causation path between the endogenous variables included in a panel VAR model. For the rest of the paper, when we talk about causality we refer to *Granger causality*.

We first consider panel VAR (τ_i) model with p variables:

$$y_{i,t} = \mu_i + \sum_{\tau=1}^{\tau_i} \Phi_{i(\tau)} y_{i,t-\tau} + u_{i,t} \qquad i=1,\ldots, N;\ t=1,\ldots,T \tag{1}$$

The index i denotes each cross-sectional unit, t denotes the time periods. μ_i is a $(p \times 1)$ fixed effects vector, and $\Phi_{i,1}, \ldots, \Phi_{i,\tau_i}$ are $(p \times p)$ matrices of parameters. $u_{i,t}$ is $(p \times 1)$ of error terms, which are independently and identically distributed.[4] Finally, τ_i is the order of the autoregressive process.

Recent developments in panel data econometrics (Emirmahmutoglu and Kose, 2011; Dumitrescu and Hurlin, 2012; Emirmahmutoglu et al, 2016) have focused on developing causality tests in a multivariate framework by conditioning on a third relevant variable. Moreover, it is well worthwhile to link these developments to those seen in the graph-theoretic method and the theory of causal discovering (see Spirtes *et al*, 2000, for a complete description). Consideration of both strands of literature together helps to highlight the relevance of determining any existing links among the different variables in a multivariate framework (see Demiralp and Hoover, 2003, for an extended explanation).

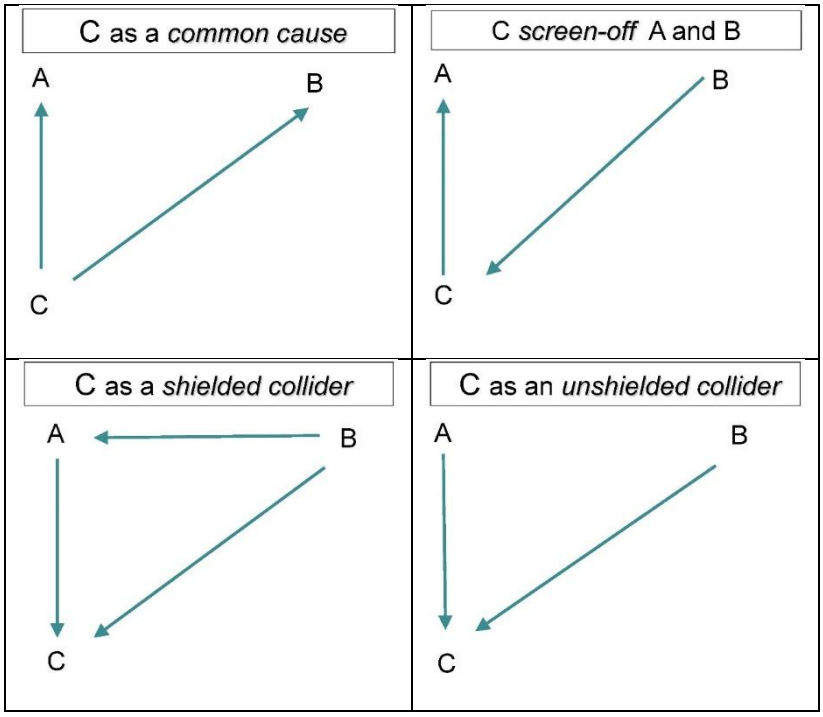
For clarity of presentation, we consider a vector Y=[A, B, C], where C may be a third variable or the final result of a more complex network of indirect links among the remaining variables included in Y. Figure 1.1 illustrates the underlying dependencies which may coexist among variables. Firstly, looking to the top-left panel, it could be the case that C is a common cause shaping the relationship between A and B. Under such circumstances, the omission or inclusion of this information in our estimation procedure would determine the final output and, consequently, the conclusions derived. Secondly, in the top-right panel, we include an alternative scenario in which the *third* variable(s) also play an important role. Indeed, in this case A and B could be dependent, and even if there is no direct link between them, we always identify a variable (C) connecting them through an indirect link. Thirdly, in the bottom panels we present two different scenarios in which variable C is a collider, in the sense of an arrowhead coming together

[3] We have developed a model-independent implementation of our methodology in MATLAB which allows for the estimation of multivariate models including more than three endogenous variables. It is available upon request by e-mail.

[4] $E(u_{i,t}) = 0$; $V(u_{i,t}) = \sum u_{i,t}$

at this point, no matter whether A and B are directly connected (bottom-left) or not (bottom-right) when we condition on C.

Figure 1.1 Theoretical illustration of conditional dependency within a multivariate framework.



Source: Own elaboration from Demiralp and Hoover (2003)
Note: C may be just one variable or a more complex structure of indirect links between a set of third variables.

Turning to the presentation of the stages of our proposal, the first step is the exploration of the degree of association between variables. In order to do so, we first obtain an aggregate measure that indicates both the intensity and the direction of movement between the variables included in analysis. Here we follow David (1949), who outlined the following procedure to obtain an overall measure of dominant correlation. First, the author proposes using Fisher's transformation to normalize the distribution and stabilize the variance of the correlation coefficients in order to make them suitable for combination. Once the coefficients have been normalized, they are averaged in order to later undo the transformation and obtain the aggregated correlation coefficient that summarizes the information contained in the combined correlation coefficients. In formal terms, the procedure described above can be written as follows:

Step 1: Let $r_1, \ldots, r_N$ be all the correlation coefficients we want to combine. To combine all the correlation coefficients into a common metric (R)[5], we first need the Fisher transformation of each r_i, which is defined by:

$$z_i = 0.5 * \ln \frac{(1 + r_i)}{(1 - r_i)} \quad (2)$$

Each z_i is approximately normally distributed with variance $\frac{1}{T_i}$, where T_i is the sample size used to calculate r_i.

Step 2: Using these transformations, the summary coefficient *(Z)* of the correlations may be calculated as the sample mean:

$$Z = \sum \frac{z_i}{N}$$

This expression is then approximately normally distributed with variance $\frac{1}{\sum_{i=1}^{N} T_i}$.

Step 3: Once we have calculated *Z,* we can undo the transformation to summarize the dominant correlation coefficient.

$$R = \frac{e^{2Z} - 1}{e^{2Z} + 1}$$

With the above statistics, we can compute a measure for the whole sample of individuals, but we can also calculate it for a subgroup which can then be used as a robustness check and to facilitate the discovery of group patterns. All in all, it can inform us about the intensity of the relationship for any pairwise of variables and classify them conveniently, according to a preset scale (in absolute terms) which varies from 0 to 1. Thus, the first range covers values from 0 to 0.2, evidencing a weak correlation. Second, a medium correlation is ranged between 0.2 and 0.5. Third, a strong correlation would be established in the range between 0.5 and 0.8; and finally, we could talk about a very strong correlation for values above 0.8. Moreover, the sign of the dominant CCF also illustrates about whether the relationship is direct (if positive) or inverse (when negative).

The next step in our proposal focusses on assessing the existence of an ultimate Granger causality path. To do so, we carry out the standard causality test, which as noted consists in testing the significance of the matrix of linear parameters $\Phi_{i,s}$. In the case of Granger non-causality, the null hypothesis for the *i-th* individual is defined as:

$$H_0 : \Phi_{i,\tau} = 0 \text{ for all } i$$

[5] Proxy to population correlation

Following Emirmahmutoglu and Kose (2011) and Dumitrescu and Hurlin (2012), among others, and with the aim of obtaining the common measure for the whole panel (jointly, with any meaningful subset of units), we carry out Fisher's transformation. Fisher (1932) proposed the following transformation of the individual p-values *(p_i)*.

$$\lambda = -2\sum \ln p_i \tag{3}$$

where p_i is the p-value corresponding to the *i-th* individual cross-section. This test has a chi-square distribution with *2N* degrees of freedom and serves to determine the existence of a common causality pattern for the included units.

Once the test has been computed for all the units, the processes of depuration and obtention of the causal graph can be carried out. In this context, we propose using the PC algorithm in its stable version to carry out the causality analysis (Colombo and Maathuis, 2014)[6]. This is an iterative algorithm based on qualitative information about whether a particular local conditional independence constraint holds, as all available information is sequentially included. The steps in the algorithm are the following (Demiralp and Hoover, 2003)[7]:

1. Start with a graph ***G*** in which each variable is connected by an edge to every other variable (*a complete undirected* graph).
2. Set *n* = 0. Test for *n*th-order conditional causality between every pair of variables conditioning on every subset of variables of size *n*. (For *n* = 0, the conditioning set is the null set, so that conditional relation is equivalent to unconditional relation.) If a pair of variables is conditionally unrelated, we eliminate the edge between them.
3. Set *n* = *n* + 1 and successively repeat step 2 until all possible conditionings set have been exhausted. Call the resulting graph **F**.
4. Consider each pair of variables (*X* and *Y*) in **F** that are unconnected by a direct edge but are connected through an undirected path through a third variable (*Z*). Orient *X—Z—Y* as *X*→ *Z* ←*Y,* if and only if *X* and *Y* are dependent when conditioned on every subset of variables, excluding *X* and *Y,* that includes *Z*. Call the resulting graph **F'**.
5. Repeat until no more edges in **F'** can be oriented: if *X*→*Z* and *Z* –*Y* and *X* and *Y* are not directly connected, then orient *Z* – *Y* as *Z*→*Y*.

To keep things simple, at the final stage of the process, whenever a robust causal relationship is found to exist between a pair of variables, there is said to be an 'oriented edge' between them.

[6] The main difference between the original version and the stable version is that the stable version of the algorithm maintains unchanged the adjacent sets of nodes at each particular level. Thus, the output is independent of the order of the variables.

[7] See Appendix A (Figures A1.1 and A1.2) for more details.

This edge indicates not only the existence of the relationship but also the sense of the link (which variable leads) and the intensity of the relationship (measured in our case as the dominant crossed correlation function).

Note that the above procedure is also valid for any kind of relationship, although, as mentioned, in this paper we focus on causality.

3. Empirical illustrations

3.1 An application for the prevalence of Phillips Curve in the EMU period

In this subsection, we illustrate the advantages and versatility of our first proposal. Here we revisit the so-called Phillips Curve for the case of euro area-12 countries during EMU period (2003-2019), which refers to the inverse relationship between inflation and unemployment rate (see Phillips, 1958). The subsequent years were not only fruitful for the academic discussion of the universality of this concept (see Friedman, 1968, among others) but also for identifying the channels driving this nexus[8]. In a recent study, Gordon (2018) revisits this analysis from the Keynesian perspective, by adding to the discussion the inertia in price and wage setting. Thus, for any given growth of nominal GDP, higher inflation implies slower real GDP growth and higher unemployment. He argues that this 'triangle' model based on demand, supply, and inertia worked well to explain why inflation and unemployment relationship were time-varying the latest decades (from the 1960s).

After the emergence of the COVID-19 crisis and the Ukraine War, we have observed an increase in interest in the phenomenon of inflation, driven by the widespread price hikes experienced during the pandemic, jointly with the conflict between Russia and Ukraine has only heightened these price tensions, particularly energy prices.

Some of those studies focus on countries of the Euro Area, as they were primarily affected by the inflation shock. Among others, Bobasu et al (2023) analysed the effect of prices across households. A common feature for most of these studies has been their focus on the effects of the specific episode. However, in our view, to effectively address these effects, it is essential to have prior full knowledge of the dynamic's dependencies among the different variables in the preceding period.

As explained in previous sections, our approach aims to adopt a comprehensive framework where the different endogenous variable is included and may play a relevant role in shaping the overall ultimate dynamic pattern. Consequently, we consider a dataset including seven alternative

[8] See Friedman (1968); Phelps (1967, 1968); Lucas (1972, 1973); Sargent and Wallace (1975); Lucas and Sargent (1978); Gordon (1982) Gordon (2013); Watson (2014); Blanchard, Cerutti and Summers (2015), Coibion and Gorodnichenko (2015); Kiley (2015); Blanchard (2016); Murphy (2018); Hobijn et al (2023).

indicators: (i) inflation, (ii) unemployment rate, (iii) nominal gross domestic product, (iv) total private consumption and (v) wages. This set of indicators allows to compare Gordon (2018) framework in terms of our methodological approach. Moreover, we extend it by including the potential role of financial constraints - (vi) borrowing costs for families, and, finally, the role of expansionary/restrictive public spending policies. In this regard, our indicator is total public expenditures (vii).

Of course, we are aware that such a complex network of relationships has been thoroughly explored in the literature (see Table 1.1) from various perspectives. However, in our view this illustration includes not only some interesting novel features but also may help to make explicit the strengths our methodology.

Table 1.1 Linkages between wages-prices-inflation nexus

Relation	**Source**
Unemployment ⇒ Inflation	Friedman (1968); Phelps (1967, 1968); Lucas (1972, 1973); Sargent and Wallace (1975); Lucas and Sargent (1978); Gordon (1981) Gordon (2013); Watson (2014); Blanchard, Cerutti and Summers (2015), Coibion and Gorodnichenko (2015); Kiley (2015); Blanchard (2016); Murphy (2018); Hobijn et al (2023)
Unemployment ⇒ GDP	Okun (1963); Lee (2000); Prachowny (1993); Weber (1995); Moosa (1997); Gomme (1999); Sögner (2001); Kreishan (2011); Ball et al (2017)
Unemployment ⇒ Private Consumption	Bande et al (2011); Ganong and Noel (2019)
Unemployment ⇒ Public Expenditure	Michaaillat and Saez (2019)
Unemployment ⇒ Wages	Malinvaud (1982); Blanchflower and Oswald (1994; 2005); Nickell and Bell (1996); Card et al (1999); Jacobson et al. (2003); Seputiene (2011); Gregg et al. (2014); Ortego-Marti (2016); Bell and Blanchflower (2018); Blanchflower et al (2024)
Unemployment ⇒ Borrowing cost for families	Sullivan (2008)
Inflation ⇒ GDP	Kormendi and Meguire (1985); Grier and Tullock (1989); Barro (1995, 1996); Darrat (1988); Andrés and Hernando (1999); Apergis (2004); Nguyen and Wang (2010); Vaona (2012); Kim et al. (2013); Pradhan et al. (2015)
Inflation ⇒ Private Consumption	Wright (1967); Heien (1972); Juster and Wachtel (1972); Juster and Taylor (1975); Houthakker and Taylor (1966); Weber (1970, 1975); Gylfason (1981); Paradiso et al. (2012); Duca-Radu et al. (2021); McCloud (2024)
Inflation ⇒ Public Expenditure	Bullock (1934); Eltis (1983); Ezirim et al. (2008); Magazzino (2011); Korkmaz and Güvenoğlu, (2021).
Inflation ⇒ Wages	Holzman (1960); Friedman (1968); Phelps (1970); Shannon and Wallace (1985); Durevall (1999); Schmidt (2000); Mehra (1991); Jonsson and Palmqvist (2004); Kagitci et al (2011);
Inflation ⇒ Borrowing cost for families	Fischer and Modigliani (1978); Follain (1982)

Source: Own elaboration

Interestingly, we may claim that Phillips Curve holds if both variables are inversely connected in both directions (significant p-values, jointly with a negative value for the dominant Crossed-Correlation Function). More importantly, our approach helps to make explicit the mediating roles of the remaining variables of interest, to identify those playing a more determinant role for shaping the ultimate dynamic system and highlighting which transmission channels are supposed to prevail after the application of our iterative approach (PC algorithm).

The first step is the analysis of the co-movement between alternatives pairwise of variables of interest. In terms of our proposal, we consider the dominant CCF to capture the intensity of the relationship, classifying the estimates conveniently into weak (<0,2), moderate (0,2-0,5), strong (0,5-0,8) and very strong (>0,8).

Table 1.2 shows two blocks related to inflation and unemployment respectively. For each block, in the first row it can be seen the estimates for the CCF for the whole panel units. Next, it can be observed those related to two subgroups of countries (central European vs peripherical) and, finally, country-specific values for our sample period. Some interesting preliminary findings emerge. First, there is a high consensus with regard to the inverse relationship between inflation and unemployment, with the only exception of Germany. Moreover, we identify a moderate intensity for most of the units, with few exceptions as Greece (-0,86), Italy (-0,68) and Luxembourg (-0,65). It can be also highlighted that there is a high degree of heterogeneity in terms of intensity across countries (0,3 of standard deviation).

Second, the other variables of interest show opposite estimates for inflation and unemployment, informing about a common mediating role consisting of separating them. For the sake of illustration, improvements in consumption would lead to increases in inflation and decreases in unemployment, helping to reinforce their inverse relationship we analyse in this illustration.

Third, in terms of intensity, the relationship of these control variables with inflation and unemployment has some specifics. For example, borrowing costs for families has the lowest impact on unemployment but the highest on inflation. On the contrary, public expenditure, consumption and wages seem to be more correlated to the evolution of unemployment

Table 1.2 Cross-Correlation amongst variables[9].

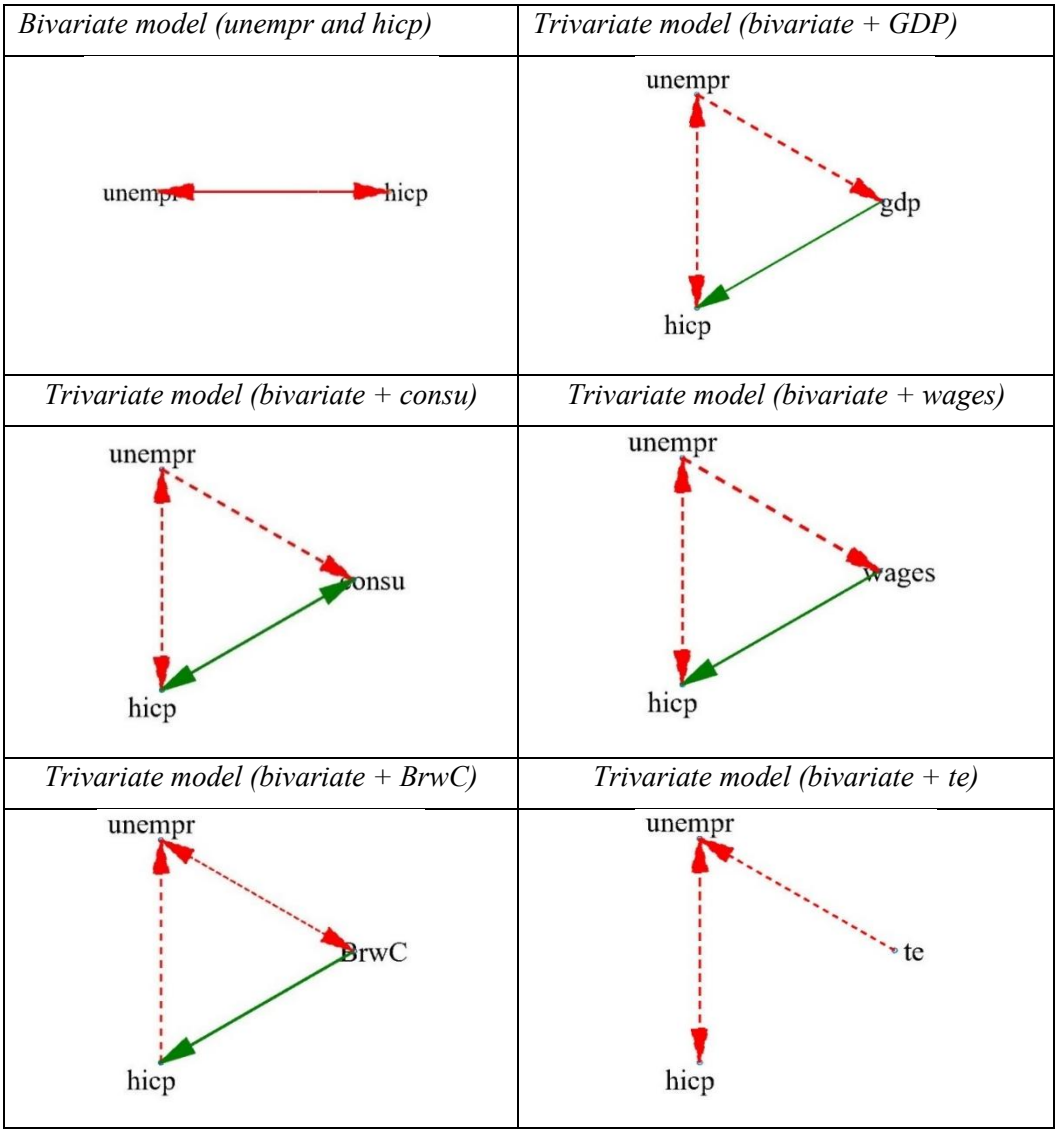
		HICP vs					UNEMPR vs				
	unempr	BrwC	consu	gdp	te	wages	BrwC	consu	gdp	te	wages
ALL	***-0,50***	**0,55**	**0,52**	**0,32**	**0,21**	**0,45**	**-0,32**	**-0,55**	**-0,47**	**-0,43**	**-0,64**
CTE	*-0,39*	0,40	0,53	0,48	0,13	0,51	-0,03	-0,34	-0,21	-0,38	-0,43
OTH	*-0,59*	0,67	0,52	0,14	0,29	0,38	-0,56	-0,71	-0,67	-0,49	-0,78
AT	*-0,42*	0,28	0,54	0,54	-0,12	0,48	-0,36	0,23	0,42	-0,26	0,44
BE	*-0,33*	0,28	0,77	0,57	0,35	0,73	0,47	-0,35	0,26	-0,28	-0,45
DE	*0,34*	0,36	0,36	0,43	-0,41	0,15	0,96	-0,51	-0,34	-0,16	-0,64
EL	*-0,86*	0,85	0,47	0,42	0,31	0,50	-0,92	-0,85	-0,86	-0,50	-0,81
ES	*-0,58*	0,68	0,55	0,41	0,43	0,32	-0,66	-0,84	-0,87	-0,75	-0,88
FI	*-0,44*	0,39	0,42	-0,41	0,53	0,49	-0,28	-0,30	-0,38	-0,41	-0,50
FR	*-0,59*	0,50	0,66	0,58	0,43	0,65	-0,64	-0,60	-0,51	-0,56	-0,58
IE	*-0,54*	0,66	0,76	0,23	0,09	0,70	-0,35	-0,76	-0,39	-0,25	-0,87
IT	*-0,68*	0,66	0,47	0,37	0,42	0,32	-0,78	-0,59	-0,44	-0,61	-0,65
LU	*-0,65*	0,58	0,41	0,46	0,28	0,56	-0,70	-0,22	-0,42	-0,34	-0,35
NL	*-0,52*	0,34	0,30	0,26	0,20	0,38	-0,54	-0,47	-0,54	-0,61	-0,75
PT	*-0,24*	0,64	0,33	-0,22	-0,14	-0,24	0,25	-0,70	-0,74	-0,25	-0,83
Memo:											
avg	-0,46	0,52	0,50	0,30	0,20	0,42	-0,30	-0,50	-0,40	-0,42	-0,57
std	0,30	0,19	0,16	0,31	0,29	0,27	0,57	0,31	0,39	0,19	0,36

Source: Own elaboration with Causality Map Toolbox

[9] Austria, Belgium, France, Germany, Luxembourg and Netherlands have been included in the Central European category, whereas Finland, Ireland, Italy, Portugal, Spain and Greece have been considered as peripherical.

Our second step is to go beyond correlation and determine whether we may expect a significant causal effect (à la Granger). In this regard, Figure 1.2 includes a selection of reduced models (bivariate and trivariate) in line with previous studies in which the causality test excludes some endogenous variables. First, the upper-left panel includes the bivariate model, for which the test confirmed that both variables are inversely connected in both directions. Second, this result is pretty robust to the sequential inclusion of a third variable, with the only exception of the impact of inflation on unemployment which becomes non-significant if we add the Borrowing cost for families. Third, we also confirm that most of the mediating variables help to shape this inverse relationship by separating them.

Figure 1.2 Multivariate causality test analysis, estimates from reduced versions of model. Bivariate and trivariate



Source: Own elaboration with Causality Map Toolbox.
Notes: (1) Results obtained from Granger's causality test at 10% of significance level, for the period 2003-2023. Solid (Dashed) line indicates that the crossed correlation between each pair of nodes is positive (negative). Finally, the wider the line, the higher this value.

Upon the basis of these results, an interesting discussion for the purposes of our approach emerges. On the one hand, four of five trivariate models find a significant effect of inflation on unemployment. On the other, one does not. This scenario suggests that we may make two alternative decisions to move towards extended versions of our model. According to Stable PC algorithm, this nexus (from inflation to unemployment) should prevail as it keeps significant for any of the model (the most conservative approach). On the contrary, the original PC would lead to reject it in the subsequent stages as there is full consensus between the alternative models.

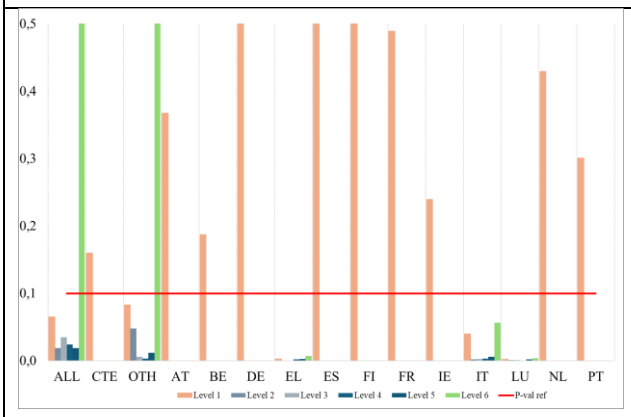
Next, Figure 1.3 shows the full iterative process described in previous sections for the main nexus under analysis; that between inflation and unemployment (Phillips Curve). For the sake of concreteness, upper panels show how conservative PC algorithm evolves over levels for the different countries and groups, whereas the bottom ones replicate the same for the original PC algorithm.

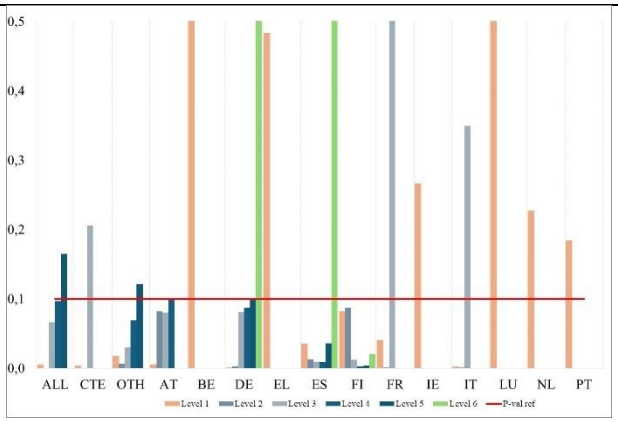
Some interesting findings may be highlighted. First, the iterative process stops when a non-significant P-value is estimated, meaning that this nexus is either not genuine or is driven indirectly throughout a different transmission channel. Second, there is mixed evidence for the different units of the panel (countries in our illustration). For instance, we find a significant ultimate nexus for Greece, Italy and Luxembourg from inflation to unemployment, but we discard it for the other countries. Third, the conservative criterion keeps more significant nexus than the original, as expected. This combined evidence helps to distinguish between those nexus/units where the significance is strong enough to survive in any criterion and those where it is dependent on the criterion assumed. Four, for the whole panel, we find a stronger nexus from inflation to unemployment compared to the opposite direction, as the non-significant p-values emerged in earlier levels.

Figure 1.3 Multivariate causality test analysis. Estimates from baseline model. Main results (p-values) for the nexus between inflation (hicp) and unemployment rate (unempr).

hicp → unempr	unempr → hicp

Panel A: PC conservative criterion

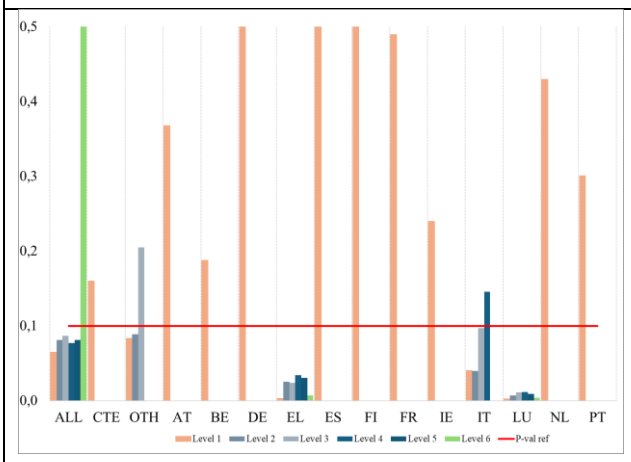


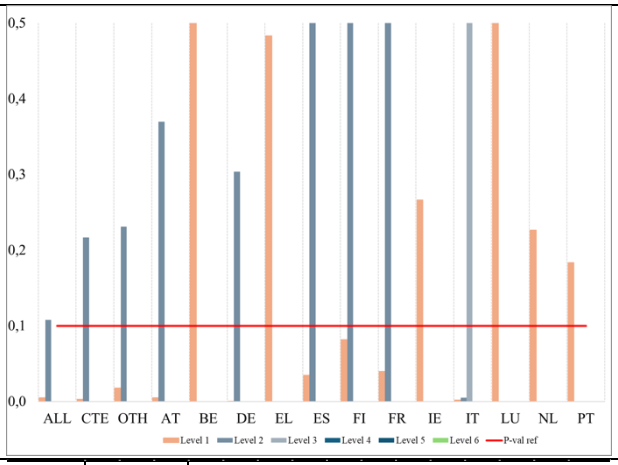


	ALL	CTE	OTH	AT	BE	DE	EL	ES	FI	FR	IE	IT	LU	NL	PT
Level 1	0,07	**0,16**	0,08	**0,37**	**0,19**	**0,88**	0,00	**0,53**	**0,68**	**0,49**	**0,24**	0,04	0,00	**0,43**	**0,30**
Level 2	0,02		0,05				0,00					0,00	0,00		
Level 3	0,04		0,01				0,00					0,00	0,00		
Level 4	0,02		0,00				0,00					0,00	0,00		
Level 5	0,02		0,01				0,00					0,01	0,00		
Level 6	**1,00**		**1,00**				0,01					0,06	0,00		

	ALL	CTE	OTH	AT	BE	DE	EL	ES	FI	FR	IE	IT	LU	NL	PT
Level 1	0,01	0,00	0,02	0,01	**0,64**	0,00	**0,48**	0,03	0,08	0,04	**0,27**	0,00	**0,79**	**0,23**	**0,18**
Level 2	0,00	0,00	0,01	0,08		0,00		0,01	0,09	0,00		0,00			
Level 3	0,07	**0,21**	0,03	0,08		0,08		0,01	0,01	**0,65**		**0,35**			
Level 4	0,10		0,07	**0,10**		0,09		0,01	0,00						
Level 5	**0,17**		**0,12**			0,10		0,04	0,00						
Level 6						**0,70**		**0,62**	0,02						

Panel B: PC original criterion





	ALL	CTE	OTH	AT	BE	DE	EL	ES	FI	FR	IE	IT	LU	NL	PT
Level 1	0,07	**0,16**	0,08	**0,37**	**0,19**	**0,88**	0,00	**0,53**	**0,68**	**0,49**	**0,24**	0,04	0,00	**0,43**	**0,30**
Level 2	0,08		0,09				0,03					0,04	0,01		
Level 3	0,09		**0,21**				0,02					0,10	0,01		
Level 4	0,08						0,03					**0,15**	0,01		
Level 5	0,08						0,03						0,01		
Level 6	**1,00**						0,01						0,00		

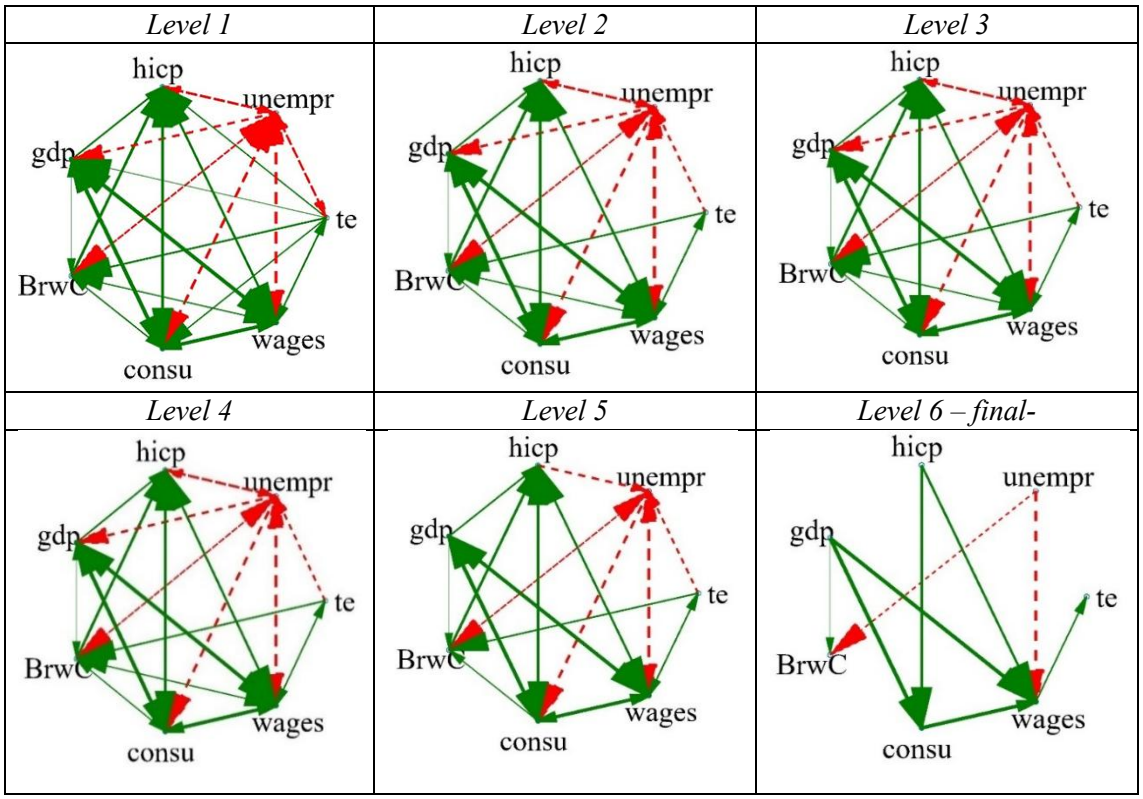
	ALL	CTE	OTH	AT	BE	DE	EL	ES	FI	FR	IE	IT	LU	NL	PT
Level 1	0,01	0,00	0,02	0,01	**0,64**	0,00	**0,48**	0,03	0,08	0,04	**0,27**	0,00	**0,79**	**0,23**	**0,18**
Level 2	**0,11**	**0,22**	**0,23**	**0,37**		**0,30**		**0,79**	**0,55**	**0,74**		0,00			
Level 3												**1,00**			
Level 4															
Level 5															
Level 6															

Source: Own elaboration with Causality Map Toolbox.

Notes: (1) Results obtained from Granger's causality test at 10% of significance level, for the period 2003-2023. Solid (Dashed) line indicates that the crossed correlation between each pair of nodes is positive (negative). Finally, the wider the line, the higher this value.

So far we have focussed on the analysis of the main nexus involved in the so-called Phillips Curve (inflation vs unemployment rate). However, our proposal allows to include relevant endogenous variables exploring the full map of nexus shaping the ultimate interlinkages. Thus, in Figure 1.4 we show the resulting causal maps for our baseline scenario: full model, assuming the conservative PC algorithm.

Figure 1.4 Multivariate causality test analysis, estimates from baseline model: main results (iterative Stable-PC algorithm)

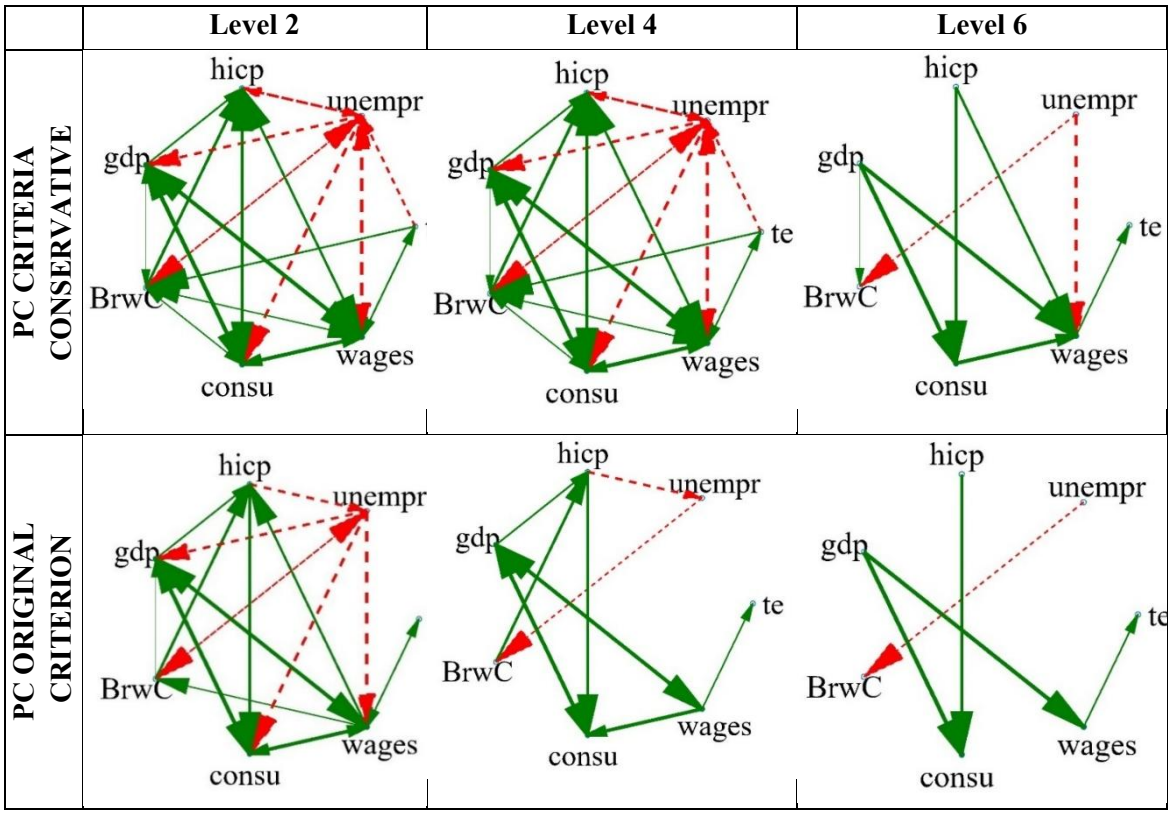


Source: Own elaboration with Causality Map Toolbox.
Notes: (1) Results obtained from Granger's causality test at 10% of significance level, for the period 2003-2023. Solid (Dashed) line indicates that the crossed correlation between each pair of nodes is positive (negative). Finally, the wider the line, the higher this value.

The main conclusions derived are the following. First, considering bivariate models (level 1) is our starting point to test how related are the variables of the model. In our illustration, our findings confirm that most the nexus are significant and bidirectional. The weakness of this finding is that we have no possibility to identify which variable is leading the internal dynamic. Second, the subsequent levels progressively reduced the existing significant nexus. For instance, the impact of unemployment on inflation becomes non-significant in level 5 and, more importantly, the map is much clearer in the final step. Third, our contribution is clear looking at the final causal map, in which we identify which variables lead the dynamic (inflation, unemployment, and GDP). On the contrary, consumption and wages reacts to their movements and, finally, borrowing costs for families and total expenditures do not influence the other nodes. Finally, we can also conclude that our main nexus of interest is not present anymore, indicating that the Phillips Curve does not prevail for these countries during the EMU period.

To check for the impact of consider the original PC algorithm, Figure 1.5 contains comparative panels for levels 2, 4 and 6 (the final one). First, one can see how a quicker depuration process of significance is obtained, compared to our baseline. Second, the main conclusions remain, as long as the leaders we identified in previous figure still keeps the same role.

Figure 1.5 Multivariate causality test analysis, estimates from baseline model: comparison of alternative PC algorithms.



Source: Own elaboration with Causality Map Toolbox.
Notes: (1) Results obtained from Granger's causality test at 10% of significance level, for the period 2003-2023. Solid (Dashed) line indicates that the crossed correlation between each pair of nodes is positive (negative). Finally, the wider the line, the higher this value.

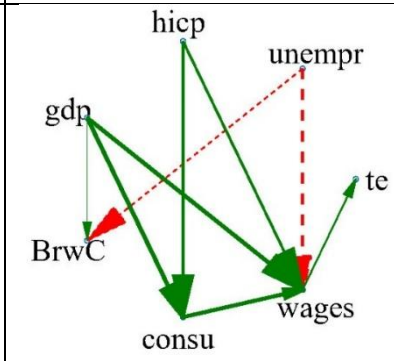
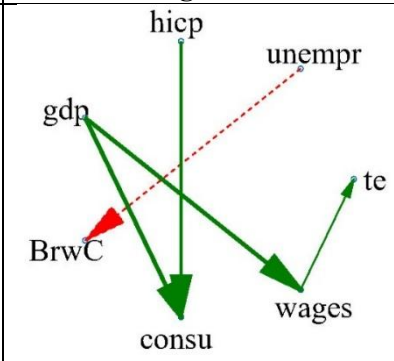
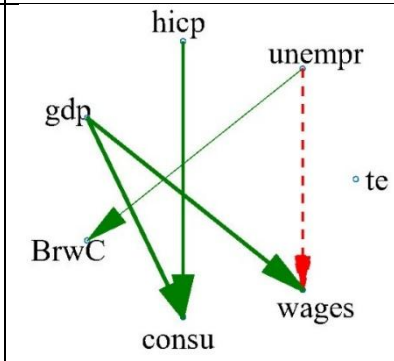
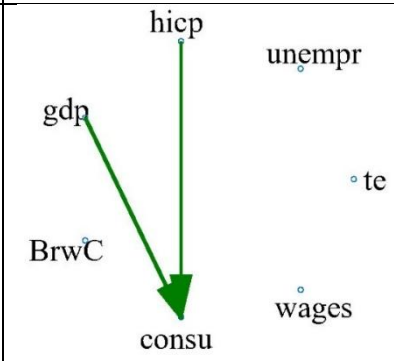
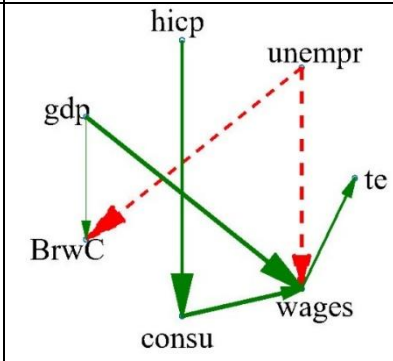
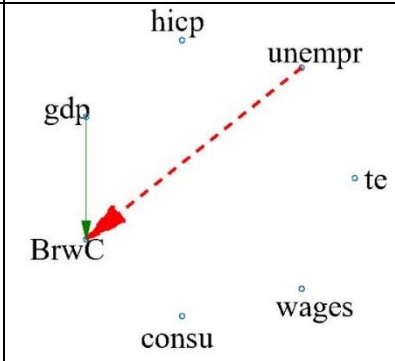
Next, we present a complementary look to our results which consists of splitting the countries of the whole panel into meaningful subsets. This could be informative in terms of identifying subset-specific profiles. Indeed, Figure 1.6 presents this piece of information when splitting the sample into the central European countries and the peripherical ones.

Looking to first column, we can see that the profiles are very similar if we consider the conservative PC algorithm. Indeed, there are only two exceptions. First, only for peripherical holds two positive links: (i) the one from GDP to borrowing costs for families, and (ii) the link from wages towards total expenditures. Second, even if the nexus from unemployment rate to borrowing costs holds for both groups, the sign of the CCF is different, showing that the direction of the impact is going to be different for each group of countries.

However, when we apply the original PC algorithm, we observe that the profiles are very different. On the one hand, for central European countries, inflation and GDP causes positively the private consumption. On the other hand, for peripherical countries, unemployment rate and GDP seems to impact on borrowing costs for families. Unfortunately, the -negative- strength of

the latter is higher indicating that keeping a sound evolution for the national labour markets is not only good for workers' income but for covering in better conditions their borrowing needs.

Figure 1.6 Multivariate causality test analysis, estimates from baseline model: comparison of groups of countries/units.

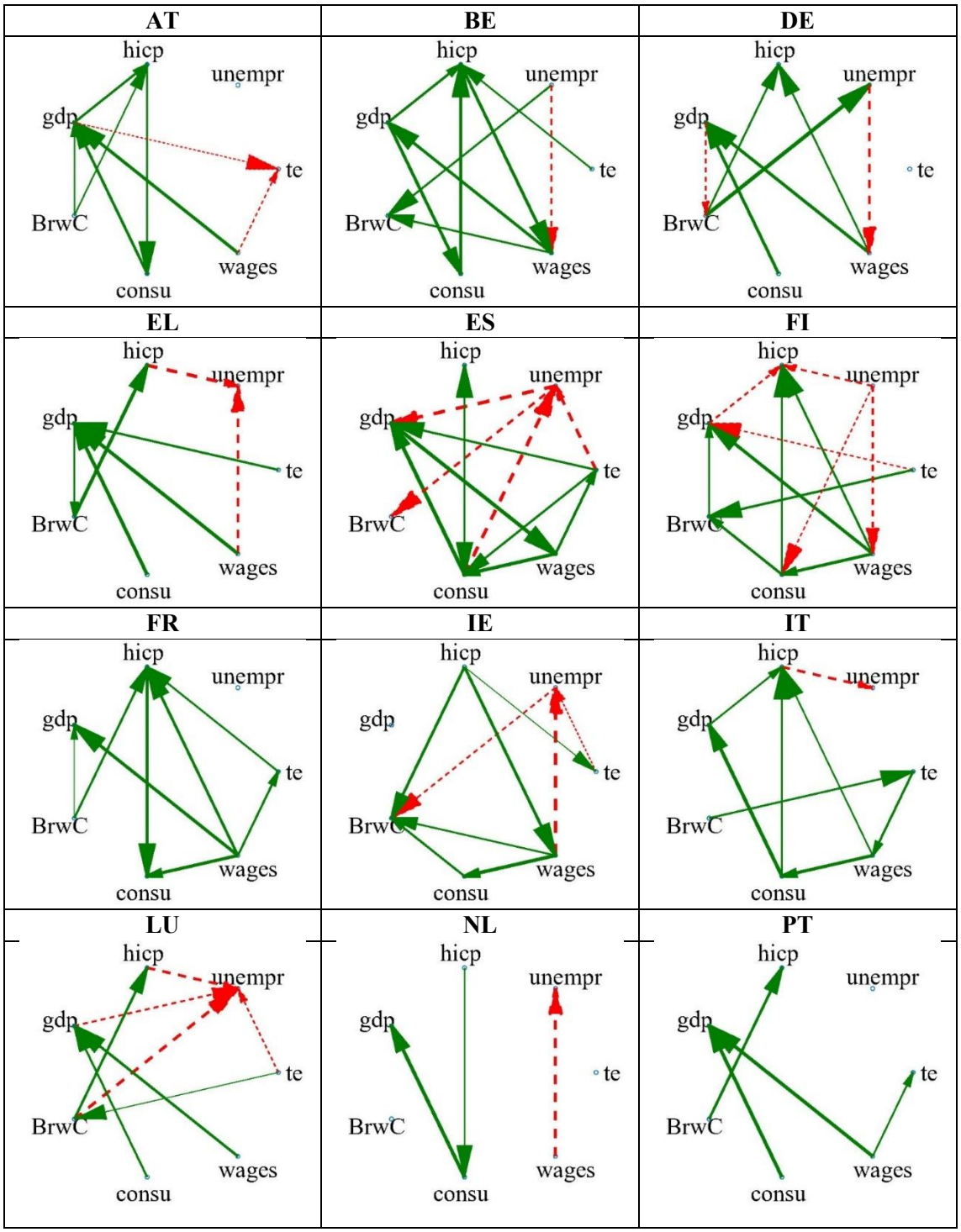
	PC conservative criterion	**PC original criterion**
Euro Area 12		
Central European countries[1]		
Peripherical countries[1]		

Source: Own elaboration with Causality Map Toolbox.
Notes: (1) Results obtained from Granger's causality test at 10% of significance level, for the period 2003-2023. Solid (Dashed) line indicates that the crossed correlation between each pair of nodes is positive (negative). Finally, the wider the line, the higher this value.

Finally, we look to the country-specific causal map (see Figure 1.7). Two general findings may be emphasized. First, the Phillips Curve only partially holds for some countries (Greece, Finland, Italy, and Luxembourg). Second, there is a high degree of heterogeneity for the different countries in terms of the underlying dynamics, indicating that even if the EMU period has contributed to harmonize prices evolution, other relevant transmission channels still comove differently according to the national characteristics of the national economies.

All in all, all these novel empirical evidence helps to emphasize one of the strengths of our approach as we identify the specific leadership at a national level but, at the same time, we are able to shape common and general patterns.

Figure 1.7 Multivariate causality test analysis, estimates from baseline model: cross-country comparison.



Source: Own elaboration with Causality Map Toolbox.

Notes: (1) Results obtained from Granger's causality test at 10% of significance level, for the period 2003-2023. Solid (Dashed) line indicates that the crossed correlation between each pair of nodes is positive (negative). Finally, the wider the line, the higher this value.

3.2 Revisiting the nexus of wages, prices and private consumption in the EMU period

In this subsection, the objective is to revisit the nexus between prices, wages and private consumption for the twelve euro-area member states in the period (1999-2019) in order to achieve a more comprehensive understanding of the preceding period of the prices hikes experienced after Covid-19 crisis and particularly since the beginning of Rusia-Ukraine conflict. This seems somehow a key feature for efficiently addressing potential challenges stemming from current shocks. In the Euro Area, inflation rose from 2.6% in 2021 to 8.4% in 2022 and 5.4% in 2023. However, the EU countries exhibited a significant degree of variability. While inflation in the Netherlands reached a value of 11.6% in 2022, in France it remained close to 5.9%. Again, this has led to the revival of old discussions that seemed to have been overcome. Of particular importance has been the debates about the relationship between inflation and wages, which echoed the episode of 1980s wage-inflation spiral.

Previously, such a complex topic has been explored intensively in the literature from various perspectives. As such, the relationship between wages and consumption has played an important role in post-Keynesian literature, particularly in growth models. Within this branch of literature, with a non-existent consensus, the so-called wage-led models state that an increase in wages and their share, through a rise in consumption , lead to an expansion of domestic demand (Kalecki (1971), Steindl (1952), Rowthorn (1981), Dutt (1984), Taylor (1985), Blecker (1989; 2011), Bhaduri and Marglin (1990) and Stockhammer and Onaran, (2013)). On the other hand, proponents of the so-called debt-led models argue that a greater increase in private indebtedness, directed specifically towards consumption, will result in an acceleration of economic activity, an increase in employment rates, and consequently a rise in wages (Candelty and Vernengo (2017)).

Regarding the wage-prices relationship, in the presence of strong general collective bargaining agreement, the phenomenon of wage indexation argues that, in order to maintain the purchasing power of workers, increases in the general price level should be simultaneously followed by increases in the nominal wage level. However, this could lead to a feedback mechanism that end up in a wage-inflationary process (Durevall (1999); Shannon and Wallace (1985)). At the same time, unit labour cost theories point out that a general increase in labour compensation will most likely be followed by a general increase in prices, as wages constitute one of the main determinants of prices (Shannon and Wallace, (1986)).

However, this mechanism can also operate in the opposite direction, which is the case internal devaluation policies. Essentially, those postulates emphasize the role of wages as an internal cost of firms and suggest the application of wage devaluation policies as a way to reduce domestic prices and to gain external competitiveness, so in that way economies could transit to export-led models. Studies analysing these claims were particularly popular in Europe during the 2008 crisis

and confronted two different economic models: those of Mediterranean economies, with uncoordinated wage bargaining and poor economic performance, and other coordinated economies, highlighting Germany as prototypical example of success in the application of internal devaluation policies (Dadush et al. 2010; Lapavitsas et al. 2012; Darvas, 2012; De Grauwe, 2012; Storm and Naastepad, 2015).

Finally, focusing on the private consumption-prices nexus, it also may operate through different channels: On the one hand, it alters the composition of the consumption-savings basket for individuals. Thus, in the face of the loss of value of money due to rising prices, it will lead to an advance in consumption at the expense of savings. However, the rise in prices also erodes the purchasing power of consumers, so it would also be plausible to expect a negative effect over consumption in lower income households.

As such, in this application, we provide an analysis of the main dynamics between wages, prices and consumption and labour market indicators for twelve euro-area member states over the periods 1999Q1-2019Q4 which makes a total of 84 observations for each country. We purposely exclude COVID19 and later data from our sample as such a strong exogenous shock could be affecting our econometric analysis. As previously mentioned, the multivariate approach proposed here allows the inclusion of other relevant economic variables that may be playing a not neglectable role in shaping the dynamics driving the relationship between our main nexus. So, we also include in the analysis other labour market indicators -labour productivity and employment rate- and economic growth. Our database is composed of the following variables: (i) Nominal Wages (*WAGE*) as a proxy of household's income; (ii) Private Consumption (*CONSU*); (iii) Harmonized Index of Price Consumer (*HICP)* as a proxy of inflation; (iv) Gross Domestic Product *(GDP)* to proxy the economic activity (v) *LPROD*, Labour productivity and (vi) TEMP, total employment (number of employees) for including labour market indicators. The selected European economies are Austria, Belgium, Finland, France, Germany, Ireland, Italy, Luxembourg, Netherlands, Portugal, Spain and Greece. The complete dataset in obtained from Eurostat.

The first step consists of analysing the expected association between variables by means of the correlation matrix for each of the countries included in our sample for the period 1999-2019, which will help us to assess some of the insight found in previous sections. In this regard, table 1 provides a detailed overview of the correlation coefficients amongst the main variables for every country included in our sample as well as the dominant cross-correlation function (CCF) which is representative of the aggregate for whole panel. As we have explained, this method enables us to exploit the cross-sectional unit's information, to understand the country-specific profiles, as well as to extract a common pattern among them.

In accordance with the previously established criteria, Table 1.3 indicates that there is a very strong -positive- correlation can be found between all pairs of variables, which means that all the variables tend to co-move in the same direction. Particularly strong seems the association between wages and consumptions, which smaller value is 0.98. Focusing know in the country-variations, every country presents a correlation coefficient between the three pairs of variables close to 1 except for Portugal, that seems to behave somewhat differently with respect to the prices. The correlation coefficient between wages and prices is 0.67 and the one between consumption and prices is 0.65, which lowers the association degree from very strong to strong. However, it is important to bear in mind that *association* between variables does not means *causality,* even in the cases where the coefficient obtained represent a very strong relationship.

Table 1.3 Cross-Correlation among prices, wages and consumption

Country	**Wages - Prices**	**Consumption - Wages**	**Prices - Consumption**
Austria	1.00	0.99	0.99
Belgium	0.99	1.00	1.00
Finland	0.96	0.98	0.98
France	0.95	0.99	0.96
Germany	0.96	1.00	0.96
Ireland	0.98	1.00	0.98
Italy	0.96	0.99	0.99
Luxembourg	0.97	1.00	0.96
Netherlands	0.95	0.99	0.97
Portugal	0.67	0.98	0.61
Spain	0.90	0.98	0.95
Greece	0.97	1.00	0.98
CTE	0.98	1.00	0.98
OTH	0.94	0.99	0.96
ALL	**0.97**	**1.00**	**0.98**

Source: Own elaboration.

Once we have checked the sing of the possible relations among our set of variables, we conduct the iterative process of the Granger causality analysis along with the application of the PC algorithm, including all possible causality links between the variables selected are examined and inspected. In this sense, in this illustration, we begin with a model of the reduced set of variables, exclusively limited to the three main variables -prices, wages and private consumption-. However, it seems clear that our control variables contribute to get a full understanding of the set of dependencies. For this reason, it is necessary to consider a second -expanded- model, where we focus on other variables closely related with the labour market and the economic cycle. Thus, our

extended model includes as endogenous variables prices, wages and private consumption as well as labour productivity, employment rate and economic growth.

Our approach begins -level 1- with bivariate tests between every combination of pairs of endogenous variables included in each model. By iteratively computing the tests and then storing the results, an analysis of all the possible bidirectional connections between variables is conducted. In this stage, those linkages where the causal relationships were not significant are excluded from further levels of analysis. For those, instead, in which a causal relationship is indeed found, the test is repeated correspondingly but controlling, independently, for the remaining endogenous variables included in each model. In this new level -level 2-, non-significant links between pairs of variables get newly excluded from the analysis and only survivant relationships will be studied in the next one. The final result is obtained throughout a computationally demanding iterative process based on the inclusion, for any additional level of analysis, of an additional variable to the control system[10]. The process is set off when the maximum level is reached. This level will coincide with the *(p-1)* endogenous system variables of each model.

Next, we will present an illustrative hypothetical example directly based on this analysis. At level 1, we will have two different set of variables. The reduced model only will include prices, wages and private consumption whereas the extended one will include also the first set plus labour productivity, total employment and economic growth. In both sets, relationships will be analysed by pairs. For instance, on the *indexation hypothesis* (PRICES $\Rightarrow$ WAGES), we start conducting usual unconditional Wald test. If this relationship is proven to be positive, we would advance to the next level in which we would repeat the test but adding one-by-one the rest of the endogenous variables of the system. In the case of the reduced model, only private consumption, the remaining endogenous variable, would be included in the control set in level 2 (PRICES $_{consu}$ $\Rightarrow$ WAGES). However, in the extended model, we will also have to include in the control set the other three endogenous variables, so we will end up by conducting the following tests (PRICES$_{consu}$ $\Rightarrow$ WAGES; PRICES $_{lprod}$ $\Rightarrow$ WAGES; PRICES $_{temp}$ $\Rightarrow$ WAGES; PRICES $_{GDP}$ $\Rightarrow$ WAGES). Thus, the reduced model will only be able to reach level 2 while the extended model will continue up to level 5.

All in all, in Figure 1.8 we have represented in the casual maps resulting for both models along the lines of graph theoretic methods for the whole panel of euro area countries, with the first and last levels of each model (level 2 and 5, respectively). It can be easily observed that in the reduced model the three variables seem to be connected. In this regard, prices play a key role, leading the

[10] The size of the control set will always be the current level of the application of the algorithm minus one. So, in level 1, the size of the control set will be zero; in level 2, will be 1, etc.

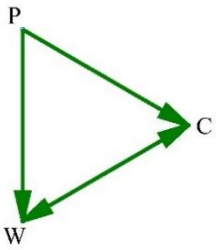
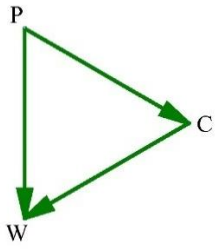
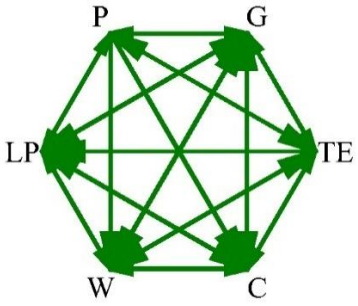
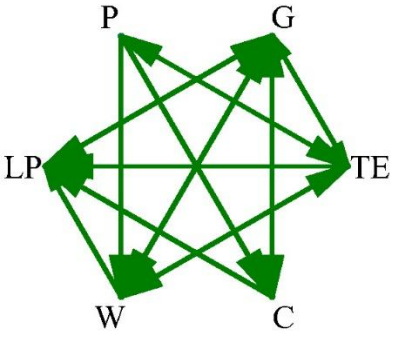
dynamics among them. In addition, the bidirectional causality between wages and consumption found on level 1 get depurated by the application of the PC algorithm, ending with consumption *positively causing* the former, strengthening the global influence of prices on wages. So, for the aggregated of countries, the indexation hypothesis seems to hold in the reduced model. Likewise, private consumption seems to be preceded by prices, so in a sense, household may be reacting to the uncertainty channel. Finally, private consumption also seems to precede wages, which may serve us a hint of the *consumption led* orientation of the group.

Nevertheless, some of these results lose validity once we transition to a complex system. In a first stage, we can observe that all the variables appear to be interconnected, without any of them seeming to lead the dynamics. However, looking closely, we notice that prices received fewer arrows than other variables, which can serve as a clue of its potential role in shaping the common dynamics. In fact, when we move to the last level (level 5) we observe that most of the interconnexion have been depurated. Indeed, prices conserve its role in explaining the most relevant linkages. Regarding our main variables, we still found the causal nexus between prices and wages and between prices and consumption that were found on the reduced model, so both *indexation hypothesis* and *expectative hypothesis* seem to hold still within the complex system.

On the other hand, the direct causal link found from private consumption to wages disappears in the extended model. In fact, it becomes an indirect link that is channelled through other variables. Thus, for example, we find a causal link from consumption to economic growth, and from economic growth to wages, which seems to confirm the signals of the *consumption led* orientation found on the reduced system.

Another interesting issue observed in the extended model has to do with the dynamics between labour market indicators. While in the reduced version wages seemed not to play any leading role, by extending the number of relevant variables it is found that, they contribute to the dynamics of the whole system causing positively to both employment rate and labour productivity (either through direct and indirect *via*).

Figure 1.8 Path obtained for the complete sample.

	Level 1	**Last level (5th)**
Reduced model		
Extended model (Ordinary PC)		

Source: Own elaboration using Causality Map Toolbox
Notes:
(1) Results obtained from Granger's causality test at 10% of significance level, for the period 1999-2019. Solid line indicates that the crossed-correlation between each pair of nodes is positive (2) : (i) Nominal Wages (*W*; (ii) Private Consumption (C); (iii) Harmonized Index of Price Consumer (*P*; (iv) Gross Domestic Product *(G)* (v) *LP*, Labour productivity and (vi) TE, employment rate for including labour market indicators

As mentioned, one advantage of this empirical strategy is that we are able to analyse not only the whole panel but also any of these countries individually. Figure 1.9 represent the individual country's p-values of last levels of each model for the relationship of our main nexus of variables. In this sense, we can examine which specific cases participate in the common findings found in the aggregate and which ones behave according to a more specific pattern.

It can be observed that in almost every country the causal path from prices to wages, becomes more significant when analysing the extended model except only for Netherlands, for which it becomes not significant. Interestingly, the opposite link, from wages to prices relationship, does not survive in practically any country (with the exception of France). Particularly it is worthy to highlight results the case of Germany, for which no causal relationship between prices and wages is found, despite being considered as the prototypical example of successful internal devaluation policies (Dadush et al. 2010; Lapavitsas et al. 2012; Darvas, 2012; De Grauwe, 2012; Storm and Naastepad, 2015).

In terms of the effect of prices on private consumption, it seems a very robust relationship, as it is significant in the complex system for all countries. However, it does not survive in Austria, Belgium, Germany, Greece and Ireland when we restrict to the reduced model. Furthermore, the

contrary seems to be observed for the arrow in the opposite direction. It does not survive for practically any country and the only case where we can find a significant relationship is in Ireland (in the reduced version of the model).

Finally, if we focus on the causal links between wages and consumption, we find that, although the degree of survival to the process of depuration in the last levels is higher (compared to previous links), this relationship tends to be much less significant. In fact, Spain (Netherlands) is the only exception for which we do find this relationship when we consider the extended (reduced) version of the model. Conversely, we find fewer cases of survival for the link from private consumption, but once we do, they tend to be significant (this is the case for France, Italy, Luxembourg and Portugal).

All in all, we can summarize all this information to test for the degree of compliance both individually and jointly with the major hypotheses explored in the literature (see Table 1.4).

Figure 1.9 P-values for a selection of bivariate relationships.

	AT	BE	DE	EL	ES	FI	FR	IE	IT	LU	NL	PT	ALL	CTE	OTH
Reduced Model	0.17			0.04			0.07	0.13		0.01	0.10	0.12	0.00	0.04	0.00
Extended SPC Model	0.06			0.02			0.06	0.01		0.01	0.57	0.05	0.01	0.06	0.02
0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1

	AT	BE	DE	EL	ES	FI	FR	IE	IT	LU	NL	PT	ALL	CTE	OTH
Reduced Model		0.04				0.02	0.00					0.19			
Extended SPC Model		0.10				0.17	0.06								
0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1

	AT	BE	DE	EL	ES	FI	FR	IE	IT	LU	NL	PT	ALL	CTE	OTH
Reduced Model	0.29	0.00			0.01	0.00	0.41		0.00	0.13	0.12	0.23	0.00	0.01	0.00
Extended SPC Model		0.00			0.00	0.02			0.04	0.00	0.02		0.00	0.00	0.00
0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1

Figure 1.9 (cont.): P-values for a selection of bivariate relationships

Source: Own elaboration using Causality Map Toolbox

Notes: (1) Blank cell indicate that the relationship do not survive to last level, so the test is not computed. (2) Results obtained from Granger's causality test at 10% of significance level, for the period 1999-2019. Solid line indicates that the crossed-correlation between each pair of nodes is positive (3) : (i) Nominal Wages (*W*; (ii) Private Consumption (C); (iii) Harmonized Index of Price Consumer (*P*; (iv) Gross Domestic Product *(G)* (v) *LP*, Labour productivity and (vi) TE, employment rate for including labour market indicators

Table 1.4 Cross-country specific results in the lines of the related literature

Relation	Hypothesis	Reduced model	Extended model	ALL
W⇒P	*Unit labour cost hypothesis*	BE, FI, FR	FR	NONE
P⇒W	*Indexation wages hypothesis*	EL, FR, LU	AT, EL, FR, IE, LU, PT	FULL
P⇒C	*Uncertainty channel*	BE, ES, FI, IT	BE, ES, FI, IT, LU, NL	FULL
W⇒C	*Debt led model hypothesis*	AT, BE, DE, EL, ES, FI, IE, LU, NL	EL, ES	FULL
C⇒W	*Consumption led model hypothesis*	FR, LU, NL,PT	IT, LU, PT	FULL
C⇒P	*Excess demand*	IE, PT	IE	NONE

Source: Own elaboration
Notes: (1) None denotes that the hypothesis does not hold in any model, full in every model and partially in either the reduced or the extended model.

4. Concluding remarks

In recent decades, Granger causality has become a transversal concept frequently included in the default toolkit of applied analysts, particularly those interested in time series analysis. The number of alternatives for implementation of this test has grown significantly over the years, but the same basic and flexible idea still operates. As Granger (2003) highlighted, this concept relies on the idea that the cause (variable X) contains 'early' information about the effect (variable Y) that is unique and found in no other variable. These two elements (determination of flow and identification of genuine causes) are included in our proposal in a very intuitive way. On the one hand, considering a multivariate framework allows one to control for the main endogenous variables of the model, particularly in the context of a Vector Autoregressive (VAR) model. On the other hand, using the PC iterative algorithm allows one to clarify any ambiguity in the causality flow and, at the same time, reject any spurious relationship potentially emerging in reduced versions of the full model (such as bivariate models).

Moreover, we also have contributed to the landscape of applied econometrics by combining graphic-theoretic methods proposed by Spirtes (2000), Demiralp and Hoover (2003), and Eichler (2007, 2012), among others, with panel data models, and this helps in identifying common patterns of causality for a representative set of crossed-section units, which can be very meaningful for specific scenarios (such as countries) as it allows the interpretation of results in a more general way. Our approach also applies alternative versions of PC algorithm, which help analysists to consider alternative scenarios in order to set how restrictive the iterative process should be in clarifying the leadership role of the variables of the model.

Finally, our methodology is illustrated by revisiting existing studies in the context of panel Vector Autoregressive (VAR) models applied to two different but closely related application. The first one refers to the analysis of the prevalence of the so-called Phillips Curve (the prices-unemployment nexus) in the context of the Economic and Monetary Union (EMU) period for a selection of European Countries (euro area 12). Our approach helps in obtaining added value, as compared to prior approaches which focused only on the bilateral or trilateral analysis leaving out all other possible flows of causality, which may affect the ultimate transmission channels.

The result of our first application help to confirm the absence of prevalence of the Phillips Curve during the EMU period for the whole panel and, additionally, for meaningful subset of countries (central European and Peripherical). This is uncovered because our approach goes beyond reduced models and consider simultaneously an expanded number of variables. We also identify the variable leading the underlying dynamic for the whole panel (GDP, inflation and unemployment rate). At national level, only four countries (Greece, Finland, Italy, and Luxembourg) partially hold a significant -inverse- relationship between inflation and unemployment rate, but not bidirectional. Finally, we also find a high degree of heterogeneity in terms of underlying dynamic indicating that country-specific policies may be needed to account for the founded nexus.

In the second application we propose to focus on the preceding COVID-19 period, revisiting the causal nexus that shapes the dynamic between prices, wages and private consumption that enables us to achieve a deeper understanding of the structural changes that were entrenched prior to the price shock. In this line, our results provide novel empirical evidence which help, on the one hand, to confirm certain hypotheses present in the literature. For example, focusing on our main nexus, we obtain a causal relationship emerging from prices to wages, supporting the wage indexation hypothesis for the aggregated as well as for Austria, Greece, France, Ireland, Luxembourg and Portugal. At the same time, it allows us to rule out hypotheses that hold in reduced models but lose significance when the model is expanded, as is the case of the direct link between consumption and wages, that was only found in the reduced system.

In addition, our approach also allows to perform several country-specific analyses, which becomes essential in order to be aware of the specificalities of each economy, something which can be fundamental in making efficient economic policy decisions in a coordinated manner, as for example monetary policy in the EA countries. In this regard, we find that Ireland is the only country where private consumption seems to transmit pressures to prices. At the same time, Mediterranean economies such as Spain or Greece seem to be closer to debt led model, where private consumption successfully drives wage levels (see Candelty and Vernengo (2017)).

To conclude, we believe that this approach may be applied to very different issues and datasets. For instance, several published studies which used reduced (bilateral/trilateral) models may now be revisited by using of our proposal, to confirm or refuse their findings. Thus, the potentialities for future research are very promising.

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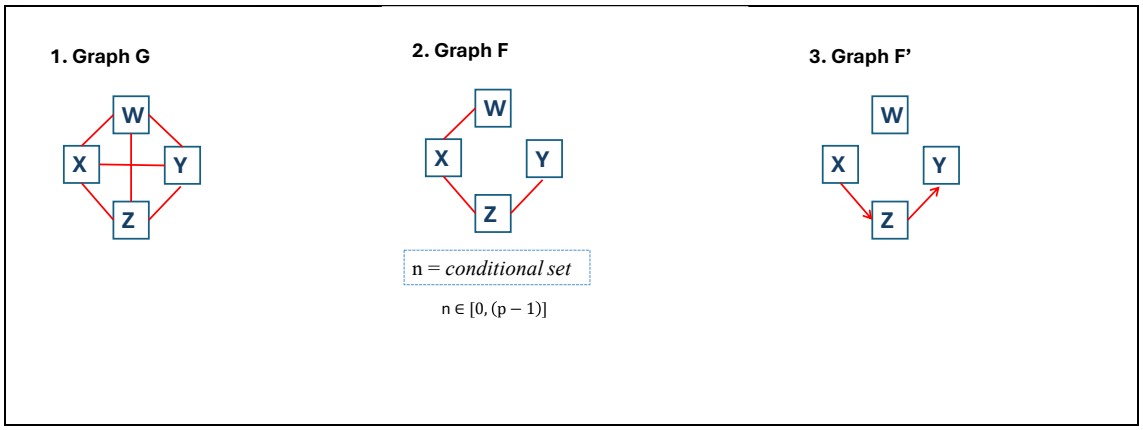
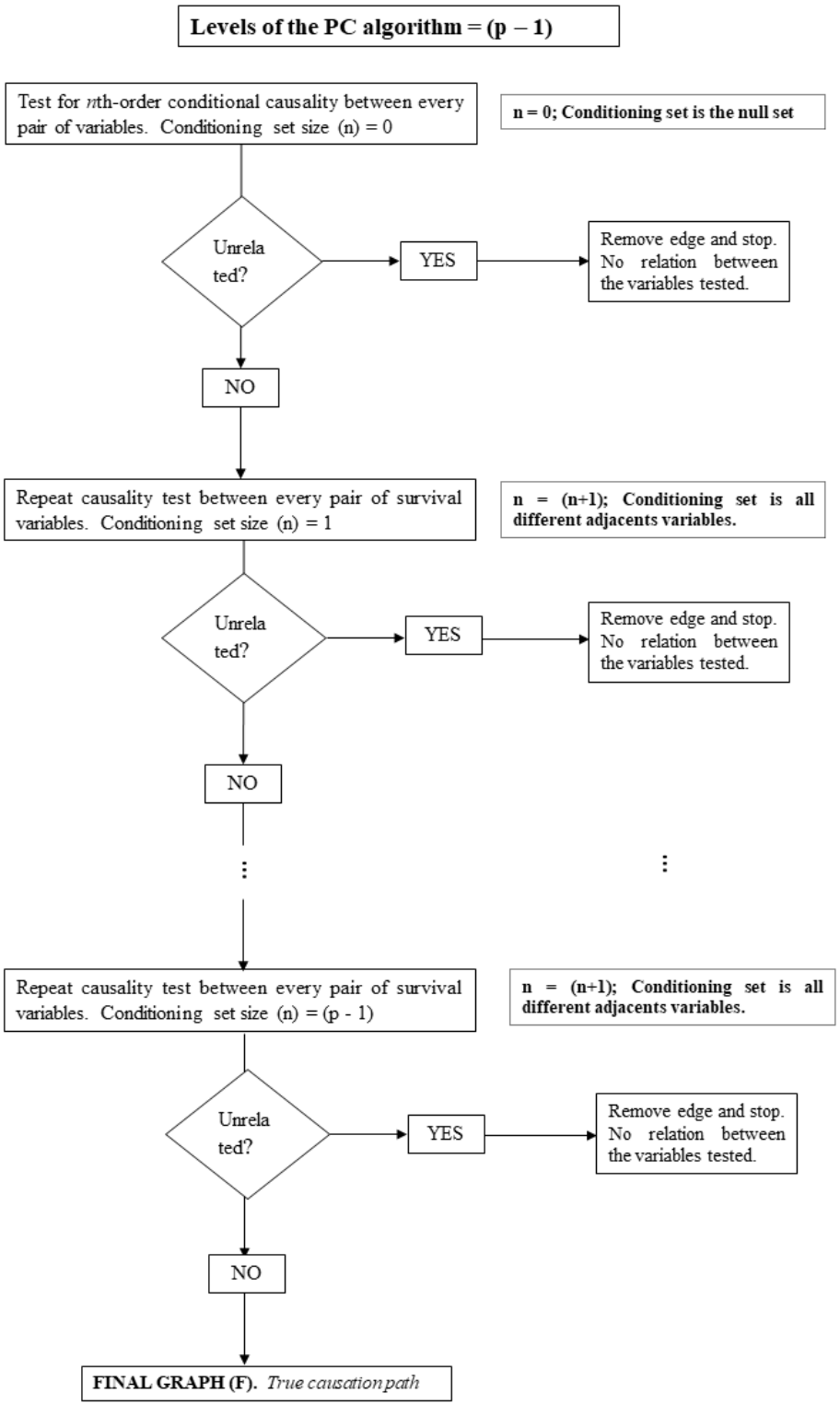
Appendix 1.1

Figure A1.1. Illustrative example of the PC algorithm steps.



Source: Own elaboration based on Demiralp and Hoover (2003) and Colombo and Maathuis (2014)

Figure A1.2. Sequential process followed by the PC algorithm.



Appendix 1.2

To implement our methodological proposal, a set of routines of MATLAB has been developed.[11] In this Annex, we present how the Toolbox computes the different steps developed on the section 3.

A1.2.1 Toolbox description

This section aims to facilitate access to this new MATLAB Toolbox, which allows to reduce entry cost of potential users. We provide a brief overview of the different files involved.

Routines description

A short description of each MATLAB independent file (which is independent on the specification of the problem to solve)

- **CausalityMapsToolbox MAIN.m**

In this function, it recovers from the Excel and all the needed information to begin the analysis and run the regressions. In order to run, this function needs (at least) two arguments:(1) ModelID and (2) DataID. The recovered info includes*:*

-*Parameters:* All the technical parameters for choosing the different model options.

-*Data:* The dataset relative to all the variables (included and excluded from the model).

-Endogenous Variables: Detects which variables will be endogenous in the model.

-*Exogenous Variables:* Detects which variables will be exogenous in the model, if any.

- **CausalityMapsToolbox_EXE_PC.m**

This function contains all the instructions for performing the causality analysis.

- **building_models.m**

Contained in CausalityMapsToolbox_EXE_PC.m, this function combines the variables to determine all possible models. Thus, it will start with the different combinations of bivariate models and will sequentially add endogenous variables until the multivariate model corresponding to the last level.

- **bar_graph.m**

This function plots every bar graph needed in the model.

- **barCCF_graph.m**

Contained in the function ResulToGraph.m, this function plots the graph of the CCF of the aggregated and the individual units of the panel (depending on the option selected) for each pair of endogenous variables.

- **barPV_graph.m**

[11] They are available upon request.

Contained in the function ResulToGraph.m, this function plots the graph of the p-value obtained from the causal analysis for the total aggregate, the groups and the individual units of the panel (depending on the option selected) for each level of the PC algorithm.

- **GrangerTestPanelVAR.m**

Contained in *CausalityMapsToolbox_EXE_PC_m*, this function calculates the main results of the causality analysis: the CCFs and the p-values of the Granger test for the total aggregate, the groups and the individual units (depending on the option selected).

- **CausalGraph.m**

Contained in the function ResulToGraph.m, this *auxiliary* function plots the causal graph resulting from the analysis for the total aggregate, the groups and the individual units (depending on the option selected).

- **causality test.m**

Contained in GrangerTestPanelVAR.m, this function is responsible for carrying out the various Granger causality tests.

- **combinings_inds.m**

This function creates combinations of variables so that all possible combinations are analysed.

- **computing_CCFs.m**

Contained in GrangerTestPanelVAR.m, this function allows to recover the dominant correlation function (CCFs)

- **creating_id.m**

This function creates ids for the different models in the analysis.

- **CTpowewr_stats.m**

This function recovers the relation between the number of significant models and the level of significance.

- **my_lrratio.m**

This function performs likelihood ratio test for VAR model to determine optimal lag length.

- **optimalVARlag.m**

This auxiliary function calculates the median value of *SIC, AIC* and *HQ* from minimum lag to maximum lag.

- **plot_CTpower.m**

This function plots the relation between the number of significant models and level of significance.

- **ResultsToTable.m**

This function produces a .xlsx file which contains the main results of the analysis (significance/p-values and CCFs)

- **ResultsToGraph.m**

This function contains and calls the rest of the graphic functions which produce the different graph of the analysis *(barCCF graph.m, barPV graph.m, Causal- Graph.m)*.

- **TOOLBOX_DIRS.m**

This function adds different folders in the current search path.

CausalityMapsToolbox folder structure

This section seeks to explain how the Causality Maps Toolbox may be used. The design of the Causality Maps Toolbox allows all analysis modifications to be carried out through an .xlsx file, which makes it user-friendly.

Figure A1 shows the structure of the folder' CMToolbox. Main folder must contain a specific folder with the name of every project (as an example: new project hereafter); CausalityMapsToolbox MAIN.m file and the toolbox folder.

In the new project folder, the main .xlsx file and the results are to be stored. Getting started with CausalityMapsToolbox: new project configuration.

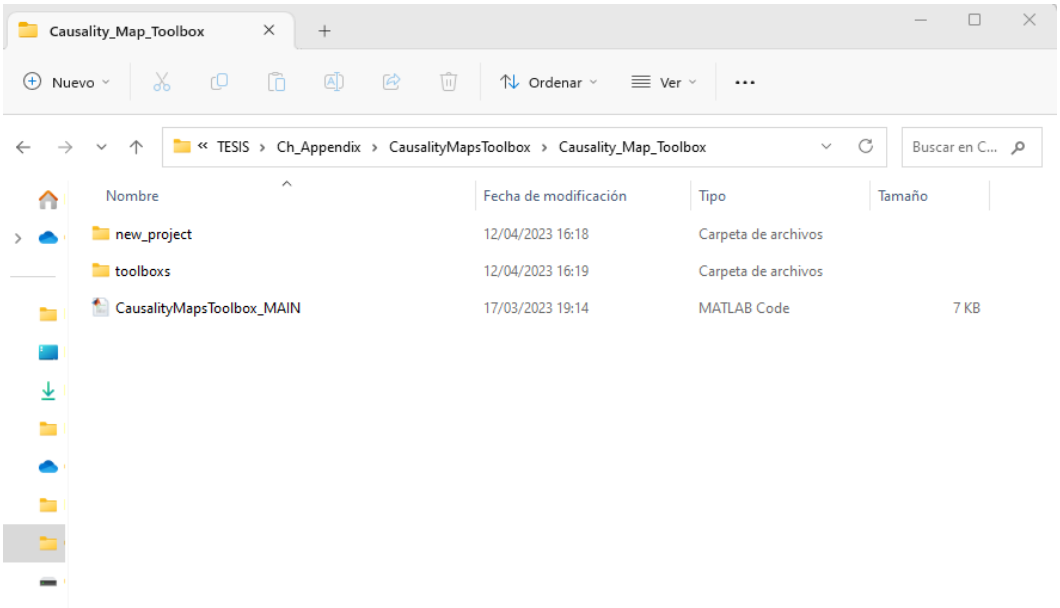
In this section seeks to explain how to configure the project for using the CMToolbox. In this sense a hypothetical example of a project (new project hereafter) will be shown. The main part in order to use the CMToolbox is to configure the .xlsx file from which the information is read. The name of the file must be formed by the name of the project plus the specific" ModelInfo" plus the execution date (2023_03 hereafter). Thus, a file named new projectModelInfo 2023_03.xlsx must be created.

The structure of the .xlsx file must always contain the following sheets:

- **PARAM:** Here the options for the parameters of the analysis should be selected. The number of parameters as well as their possible values are common for every project (Only options should be changed).
- **VARS:** Here the variables to be included in the analysis should be selected.
- **GROUPS:** Here the ids corresponding to each group and the group to include should be selected.

- **DATA SHEETS:** For each variable, a sheet containing the data must be created. There should be as many data sheet as variables likely to be used in the analysis[12].

Figure A1.2.1: Structure of the Toolbox Folder



Figures A1.2.2 to A1.2.5 show the structure that the previously mentioned sheet must follow. Therefore, Figure 2 shows PARAM sheet structure and contents. Cells A1:A14 display parameter names. Cells B1:B14 contain parameters' value. Cells C1:C14 display parameters' description. Only Cells B1:B14 are to be modified by the user.

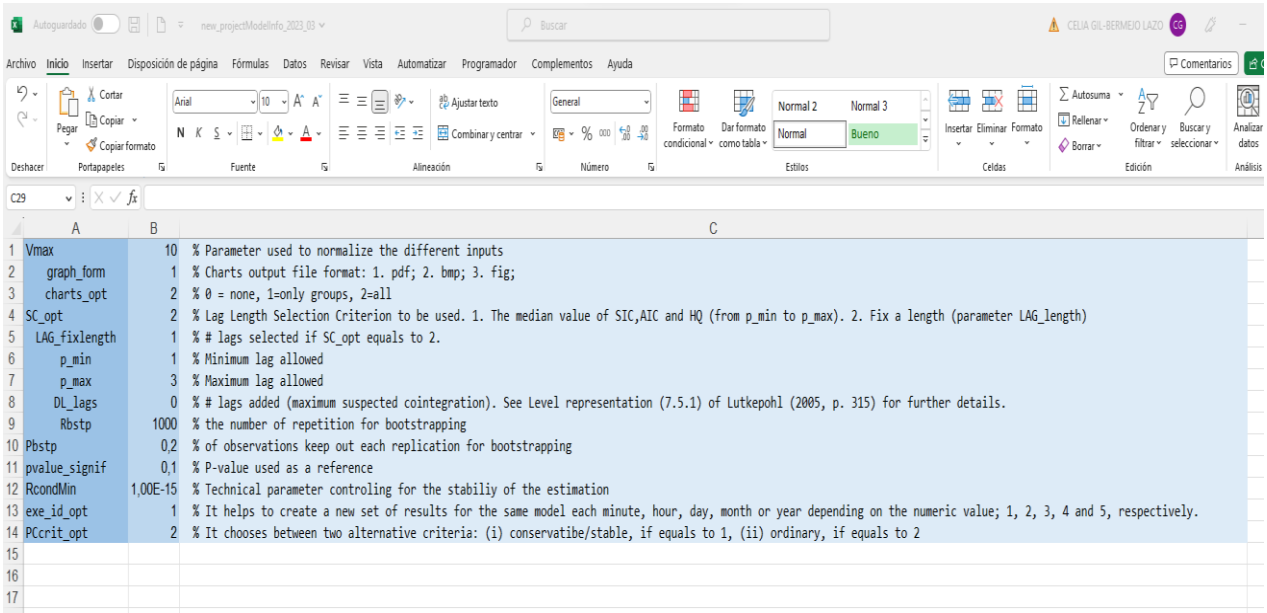
Figure A1.2.3 shows *VARS* sheet structure and contents. Columns A and B activate (designed with 1) the variables used in the analysis (endogenous and exogenous respectively). Variables designed with a 0 are not to be used. Columns C and D should contain IDs and labels of the variables respectively[13].

Figure A1.2.4 shows GROUPS sheet structure and contents. Column A activates which units are to be included. Columns B and C contain units' labels and names, respectively. Column D represents ALL the units (the whole panel) and must always be a vector of 1. Columns E onwards represent (each) one different subgroup. Units designed with a 1 are part of the subgroup. Units designed with a 0 are not. Finally, Row 1 (Column D and onwards) activate/deactivate the subgroup to be included in the analysis.

Figure A1.2.5 shows the structure *DATA SHEETS* must follow. Each sheet refers to a variable. Sheet $endo\_var_i$ only must contain the information of the i^{th} endogenous variable. The structure of the sheet should be as follows: Column A must contain the temporal units of the period considered (2004-2020 yearly in our example). Columns B onwards must contain the values of the variable for each unit (units are included then in *wide format)*

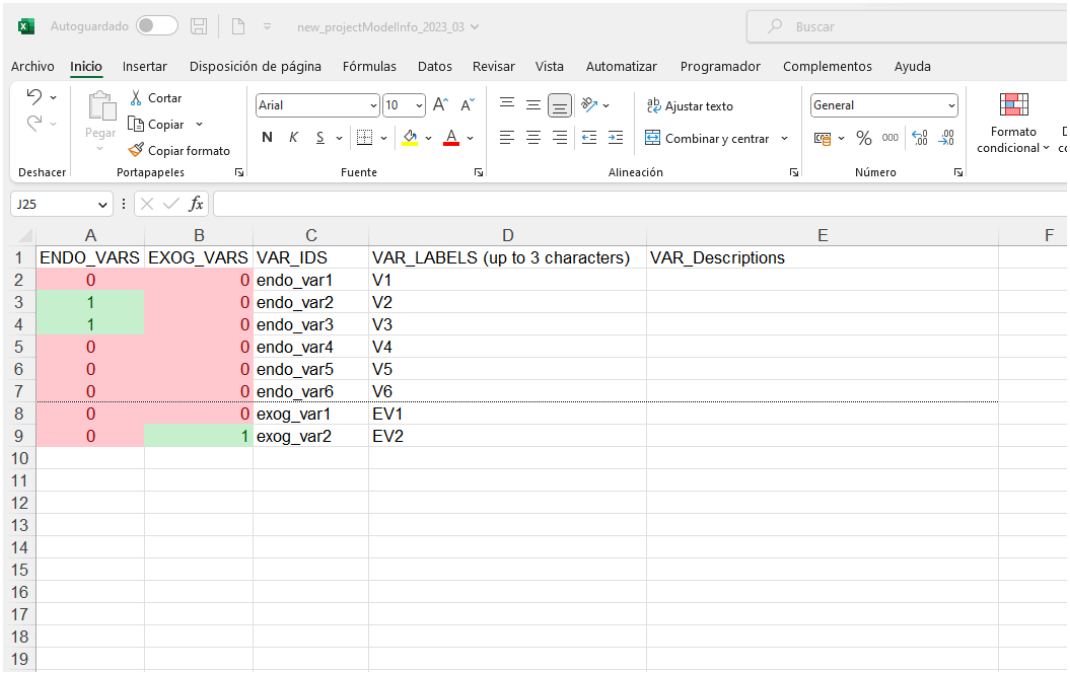
[12] Not all the variables have to be used in the same regression.
[13] In the PARAM sheet it can be chosen whether IDs or labels are used on the causal maps.

Figure A1.2.2: Sheet PARAM of the .xlsx file



	A	B	C
1	Vmax	10	% Parameter used to normalize the different inputs
2	graph_form	1	% Charts output file format: 1. pdf; 2. bmp; 3. fig;
3	charts_opt	2	% 0 = none, 1=only groups, 2=all
4	SC_opt	2	% Lag Length Selection Criterion to be used. 1. The median value of SIC,AIC and HQ (from p_min to p_max). 2. Fix a length (parameter LAG_length)
5	LAG_fixlength	1	% # lags selected if SC_opt equals to 2.
6	p_min	1	% Minimum lag allowed
7	p_max	3	% Maximum lag allowed
8	DL_lags	0	% # lags added (maximum suspected cointegration). See Level representation (7.5.1) of Lutkepohl (2005, p. 315) for further details.
9	Rbstp	1000	% the number of repetition for bootstrapping
10	Pbstp	0,2	% of observations keep out each replication for bootstrapping
11	pvalue_signif	0,1	% P-value used as a reference
12	RcondMin	1,00E-15	% Technical parameter controling for the stabiliy of the estimation
13	exe_id_opt	1	% It helps to create a new set of results for the same model each minute, hour, day, month or year depending on the numeric value; 1, 2, 3, 4 and 5, respectively.
14	PCcrit_opt	2	% It chooses between two alternative criteria: (i) conservatibe/stable, if equals to 1, (ii) ordinary, if equals to 2
15			
16			
17			

Figure A1.2.3: Sheet *VARS* of the .xlsx file



	A	B	C	D	E	F
1	ENDO_VARS	EXOG_VARS	VAR_IDS	VAR_LABELS (up to 3 characters)	VAR_Descriptions	
2	0	0	endo_var1	V1		
3	1	0	endo_var2	V2		
4	1	0	endo_var3	V3		
5	0	0	endo_var4	V4		
6	0	0	endo_var5	V5		
7	0	0	endo_var6	V6		
8	0	0	exog_var1	EV1		
9	0	1	exog_var2	EV2		
10						
11						
12						
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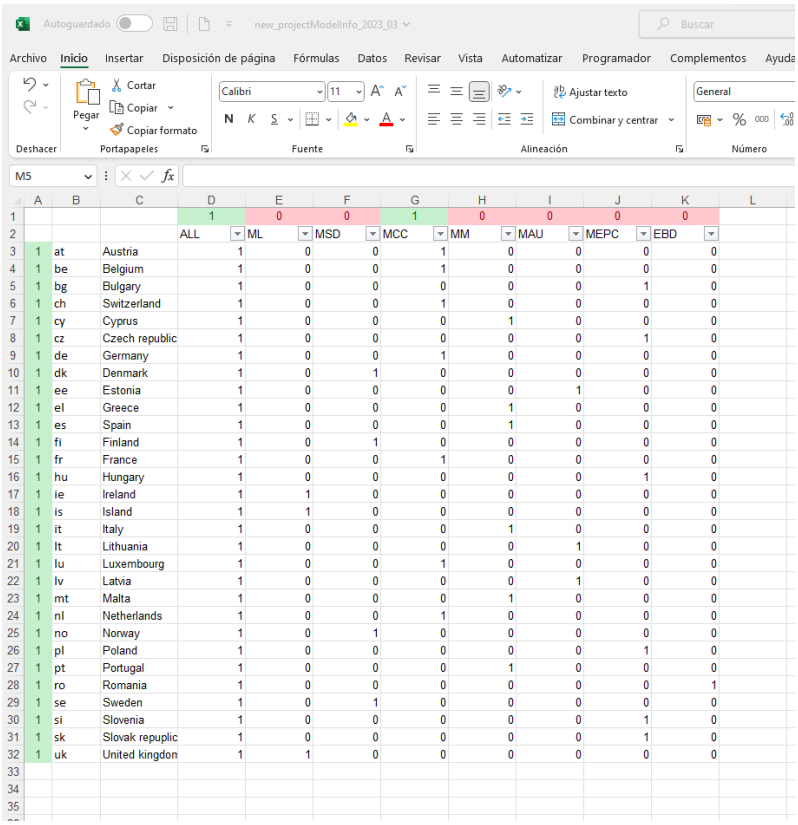
16						
17						
18						
19						

Figure A1.2.4: Sheet *GROUPS* of the .xlsx file



	A	B	C	D	E	F	G	H	I	J	K	L
1				1	0	0	1	0	0	0	0	
2				ALL	ML	MSD	MCC	MM	MAU	MEPC	EBD	
3	1	at	Austria	1	0	0	1	0	0	0	0	
4	1	be	Belgium	1	0	0	1	0	0	0	0	
5	1	bg	Bulgary	1	0	0	0	0	0	1	0	
6	1	ch	Switzerland	1	0	0	1	0	0	0	0	
7	1	cy	Cyprus	1	0	0	0	1	0	0	0	
8	1	cz	Czech republic	1	0	0	0	0	0	1	0	
9	1	de	Germany	1	0	0	1	0	0	0	0	
10	1	dk	Denmark	1	0	1	0	0	0	0	0	
11	1	ee	Estonia	1	0	0	0	0	1	0	0	
12	1	el	Greece	1	0	0	0	1	0	0	0	
13	1	es	Spain	1	0	0	0	1	0	0	0	
14	1	fi	Finland	1	0	1	0	0	0	0	0	
15	1	fr	France	1	0	0	1	0	0	0	0	
16	1	hu	Hungary	1	0	0	0	0	0	1	0	
17	1	ie	Ireland	1	1	0	0	0	0	0	0	
18	1	is	Island	1	1	0	0	0	0	0	0	
19	1	it	Italy	1	0	0	0	1	0	0	0	
20	1	lt	Lithuania	1	0	0	0	0	1	0	0	
21	1	lu	Luxembourg	1	0	0	1	0	0	0	0	
22	1	lv	Latvia	1	0	0	0	0	1	0	0	
23	1	mt	Malta	1	0	0	0	1	0	0	0	
24	1	nl	Netherlands	1	0	0	1	0	0	0	0	
25	1	no	Norway	1	0	1	0	0	0	0	0	
26	1	pl	Poland	1	0	0	0	0	0	1	0	
27	1	pt	Portugal	1	0	0	0	1	0	0	0	
28	1	ro	Romania	1	0	0	0	0	0	0	1	
29	1	se	Sweden	1	0	1	0	0	0	0	0	
30	1	si	Slovenia	1	0	0	0	0	0	1	0	
31	1	sk	Slovak repuplic	1	0	0	0	0	0	1	0	
32	1	uk	United kingdon	1	1	0	0	0	0	0	0	
33												
34												
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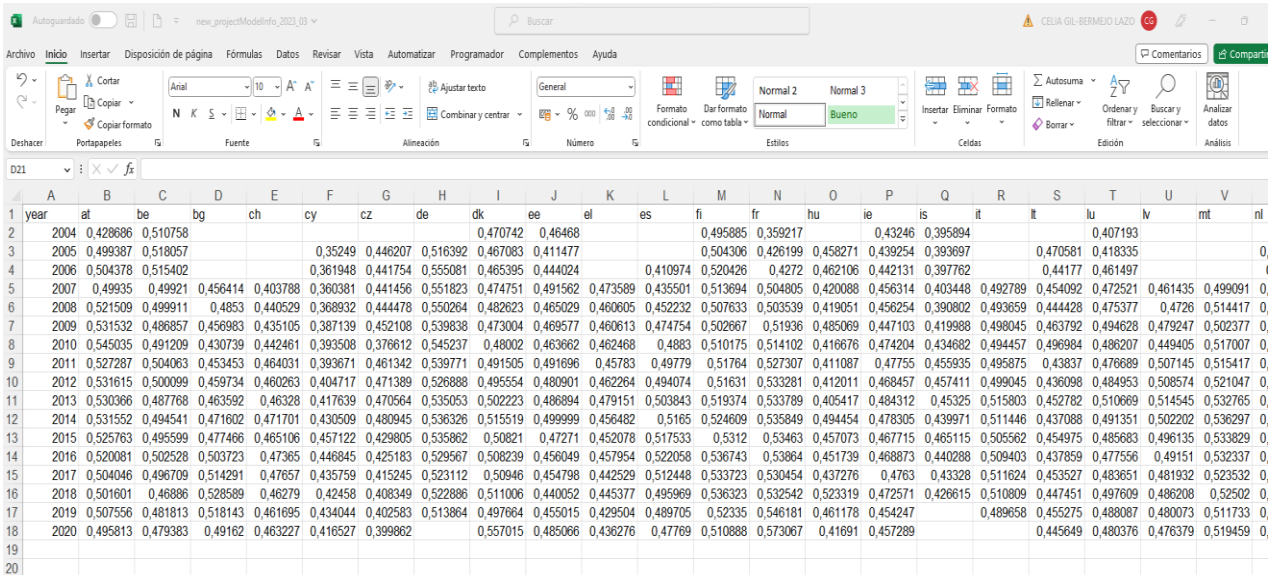
Figure A1.2.5: Sheet *data* of the .xlsx file



	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	
1	year	at	be	bg	ch	cy	cz	de	dk	ee	el	es	fi	fr	hu	ie	is	it	lt	lu	lv	mt	nl
2	2004	0,428686	0,510758						0,470742	0,46468			0,495885	0,359217		0,43246	0,395894			0,407193			
3	2005	0,499387	0,518057			0,35249	0,446207	0,516392	0,467083	0,411477			0,504306	0,426199	0,458271	0,439254	0,393697		0,470581	0,418335			0,
4	2006	0,504378	0,515402			0,361948	0,441754	0,555081	0,465395	0,444024		0,410974	0,520426	0,4272	0,462106	0,442131	0,397762		0,44177	0,461497			
5	2007	0,49935	0,49921	0,456414	0,403788	0,360381	0,441456	0,551823	0,474751	0,491562	0,473589	0,435501	0,513694	0,504805	0,420088	0,456314	0,403448	0,492789	0,454092	0,472521	0,461435	0,499091	0,
6	2008	0,521509	0,499911	0,4853	0,440529	0,368932	0,444478	0,550264	0,482623	0,465029	0,460605	0,452232	0,507633	0,503539	0,419051	0,456254	0,390802	0,493659	0,444428	0,475377	0,4726	0,514417	0,
7	2009	0,531532	0,486857	0,456983	0,435105	0,387139	0,452108	0,539838	0,473004	0,469577	0,460613	0,474754	0,502667	0,51936	0,485069	0,447103	0,419988	0,498045	0,463792	0,494628	0,479247	0,502377	0,
8	2010	0,545035	0,491209	0,430739	0,442461	0,393508	0,376612	0,545237	0,48002	0,463662	0,462468	0,4883	0,510175	0,514102	0,416676	0,474204	0,434682	0,494457	0,496984	0,486207	0,449405	0,517007	0,
9	2011	0,527287	0,504063	0,453453	0,464031	0,393671	0,461342	0,539771	0,491505	0,491696	0,45783	0,49779	0,51764	0,527307	0,411087	0,47755	0,455935	0,495875	0,43837	0,476689	0,507145	0,515417	0,
10	2012	0,531615	0,500099	0,459734	0,460263	0,404717	0,471389	0,526888	0,495554	0,480901	0,462264	0,494074	0,51631	0,533281	0,412011	0,468457	0,457411	0,499045	0,436098	0,484953	0,508574	0,521047	0,
11	2013	0,530366	0,487768	0,463592	0,46328	0,417639	0,470564	0,535053	0,502223	0,486894	0,479151	0,503843	0,519374	0,533789	0,405417	0,484312	0,45325	0,515803	0,452782	0,510669	0,514545	0,532765	0,
12	2014	0,531552	0,494541	0,471602	0,471701	0,430509	0,480945	0,536326	0,515519	0,499999	0,456482	0,5165	0,524609	0,535849	0,494454	0,478305	0,439971	0,511446	0,437088	0,491351	0,502202	0,536297	0,
13	2015	0,525763	0,495599	0,477466	0,465106	0,457122	0,429805	0,535862	0,50821	0,47271	0,452078	0,517533	0,5312	0,53463	0,457073	0,467715	0,465115	0,505562	0,454975	0,485683	0,496135	0,533829	0,
14	2016	0,520081	0,502528	0,503723	0,47365	0,446845	0,425183	0,529567	0,508239	0,456049	0,457954	0,522058	0,536743	0,53864	0,451739	0,468873	0,440288	0,509403	0,437859	0,477556	0,49151	0,532337	0,
15	2017	0,504046	0,496709	0,514291	0,47657	0,435759	0,415245	0,523112	0,50946	0,454798	0,442529	0,512448	0,533723	0,530454	0,437276	0,4763	0,43328	0,511624	0,453527	0,483651	0,481932	0,523532	0,
16	2018	0,501601	0,46886	0,528589	0,46279	0,42458	0,408349	0,522886	0,511006	0,440052	0,445377	0,495969	0,536323	0,532542	0,523319	0,472571	0,426615	0,510809	0,447451	0,497609	0,486208	0,52502	0,
17	2019	0,507556	0,481813	0,518143	0,461695	0,434044	0,402583	0,513864	0,497664	0,455015	0,429504	0,489705	0,52335	0,546181	0,461178	0,454247		0,489658	0,455275	0,488087	0,480073	0,511733	0,
18	2020	0,495813	0,479383	0,49162	0,463227	0,416527	0,399862		0,557015	0,485066	0,436276	0,47769	0,510888	0,573067	0,41691	0,457289			0,445649	0,480376	0,476379	0,519459	0,
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Chapter 2

Inequality and poverty in EU. In search of lost dynamic

Abstract

This paper analyses the dynamic relationships between income inequality, monetary poverty and economic growth for a sample of 30 European economies over the period 2003-2019. To do so, we adopt a novel approach based on a dynamic analysis that considers the variability that can occur in the evolution of these relationships over the period analysed. The proposed panel-VAR model allows us to perform a Granger causality analysis between the variables mentioned. In a second stage, we complete this analysis with application of the iterative PC algorithm that allows us to interpret the results of the model by defining the corresponding causal graphs. For the empirical analysis we use micro-data from the EU-SILC database for the period 2003-2019. The results obtained show that, for the set of countries analysed, economic growth has a positive effect on income poverty. At the same time, we found inequality has a positive effect on poverty. We also find that this dynamic is reversed, with a double positive causality between these variables, which goes in line with pro-rich literature. In addition, we do not find evidence of a poverty- or inequality- reducing effect of economic growth. However, we find that these results differ across countries, showing great heterogeneity between different tax-benefit systems.

1. Introduction

One of the fundamental pillars of action for the European Union, along with ensuring economic growth, has always been the achievement of common social welfare objectives directly linked to resource distribution. We can trace the earliest mentions of the social objectives in the foundational documents of the EU (the Treaty on the Functioning of the European Union) to the Union's own action plans, such as the European Pillar of Social Rights (ESPR), framed within the European Semester. However, during the last two decades, various events occurred that undoubtedly influenced the evolution of different social dimensions as well as challenged the economic growth path. The enlargement of the EU to Eastern European countries (with a relatively lower level of development compared to other states), the 2008 financial crisis and subsequent Sovereign Debt crisis (which primarily affected southern countries), the austerity era that followed the economic downturns and an uneven pace of economic recovery all impacted the evolution of the analysed phenomena.

The nature of the relationship between economic growth and various distributive phenomena is a fundamental issue in economic analysis. Although the number of research that focus on this issue has increased in recent years, there is no consensus on the sense of the relationship from either a theoretical or empirical point of view. In this paper we aim to contribute to the literature by applying a new methodological approach to analyse, from an empirical perspective, the dynamic causal relationships between inequality, poverty and economic growth in 30 European economies for the period 2003-2019. In this regard, the objective of the study is not so much to identify a localized causal effect at a specific point in time, typically pursued through causal inference techniques, but rather to concentrate on the dynamic relationship among the three phenomena over a sufficiently extended period to capture medium-term structural dependencies. This is why we consider appropriate to rely on the concept of Granger causality.

For our strategy for empirical analysis, we follow the approach developed in Chapter 1, where we propose a method to addressing Granger causality in a multivariate framework. The approach proposed involves, first, establishing the baseline specification, which consists of a panel-VAR model that includes the variables mentioned above. Subsequently, a causality -in terms of Ganger causality- analysis is conducted by transforming the p-values obtained from performance of a Granger causality test for each of the possible relationships[14]. On a second stage, all the information is combined and completed through application of the iterative PC algorithm, in the stable version introduced by Colombo and Maathuis (2014), which allows us to interpret the model results in line with the causal graph literature (Lauritzen and Richardson, 2002; Demiralp

[14] This procedure is based on Dumitrescu and Hurlin (2012) and involve, for all the cross-sectional units, averaging the Wald test statistic through Fisher's transformation.

and Hoover, 2003; Eichler, 2007). This algorithm provides a useful and novel tool with which to clarify inconclusive relationships.[15] Such algorithms are based on conditional independence tests to obtain information about the underlying causal structure of a given phenomenon (Spirtes et al., 2000). Here we rely on two branches of literature which, to our knowledge, have hitherto been independent of one another: that which studies causality in panel-VAR models, and that dedicated to graphical methods.

The advantages of our proposed approach are related to certain methodological difficulties encountered in the existing literature. First, we carry out a dynamic analysis that takes into account the variability that can occur in the evolution of these relationships over the period analysed. Furthermore, our methodological approach does not impose an *a priori* causal structure but explores patterns of dependence present in the data, considering the potential existence of all directions of causality. In this sense, the methodology used in this study represents a new approach to analyse the dynamic relationships between economic growth, inequality, and poverty, avoiding the establishment of a predetermined sequence of interactions, something that, in our view, could influence the results. Moreover, the results derived from the approach that we apply here are not limited to the study of correlation but are interpretable in terms of causality (Granger causality). At the same time, this approach allows us to increase in our analysis the number of relevant variables, which are usually reduced to two in causality studies using panel-VAR models. Finally, the versatility of the methodology we propose enables us to obtain results for both the total number of countries in the sample, individually and jointly as a whole, thus facilitating the application of robustness analyses that, in turn, allow for the identification of common patterns. The use of this methodology has been applied to other topics within the applied economic analysis (Golpe et al, 2023).

The remainder of the paper is structured as follows. Section 2 conducts a literature review of both theoretical and empirical works. Section 3 describes the data used and offers an initial descriptive analysis. In Section 4 we present the proposed methodology, and in Section 5 we present the results. Finally, Section 6 concludes.

2. Literature Review

Although studies analysing the relationships between inequality, poverty and economic growth are numerous and diverse, one could credit the seminal work of Kuznets (1955) as the starting point for the development of this branch of literature. In an effort to synthesise, and without the

[15] Algorithms of this type have been commonly used in other areas of knowledge, although they are increasingly being applied to a variety of economic research questions.

intention of offering an exhaustive overview, we here review the main strands of literature relating to our study.

Firstly, this work is strongly related to analyses of the relationship between inequality and economic growth from an analytical point of view. There are several mechanisms that might explain the positive and negative effects of inequality on economic growth.

We found numerous theoretical works suggesting different transmission mechanisms through which a negative relationship would occur, meaning that inequality produces a disincentivising effect on growth. The first of these mechanisms refers to political decisions as a fundamental channel. Faced with a highly unequal distribution of income, a society may well demand policy options that include redistributive policies, with capital as the main target, or else programmes that reduce reliance on pro-business policies. In such cases, the reduction in economic growth would conceivably occur through the implementation of these policies. An alternative but strongly related transmission mechanism predicts that social discontent derived from high and prevailing levels of inequality could translate into episodes of violence and social conflict, which would directly damage economic growth by reducing institutional credibility and the destruction of assets. Within this group are works by Bertola (1993), Alesina and Rodrik (1994), Persson and Tabellini (1994) and Perotti (1996). Finally, we find studies that point to underinvestment in human capital as a reason for lower economic growth (or at least growth below potential). Galor and Zeira (1993) and Galor and Moav (2004) propose a model in which, in the face of financial market imperfections, unequal distribution means that only those individuals with sufficient wealth can invest in human capital.

Also found in the theoretical literature several causal mechanisms supporting the existence of a positive effect. For instance, Kaldor (1955) and Bourguignon (1981) argue that aggregate savings and their effect on capital accumulation are among main drivers of economic growth, as channelling resources to those with a greater propensity to save (those with greater resources) has a positive effect on economic growth. We also find work predicting that high levels of inequality encourage both “hard work” and riskier financial decisions in search of higher returns, potentially having a positive effect on economic growth. (Lazear and Rosen, 1981; Okun, 1975). Similarly, Foellmi and Zweimüller (2006) propose a model in which a more equal distribution results in a disincentive to innovation and thus reduces growth.

Similarly, and directly related to our analysis, we find a large body of work that contributes to the empirical testing of these mechanisms. However, no clear consensus has been reached on the sign or intensity of the relationships in question. This body of empirical work is very diverse, which may explain the divergence in results obtained. The most significant variations arise chiefly from

the structure of the data and the estimators used, but also from the database selected and the inequality measure to be analysed.

The earliest empirical contributions used cross-sectional data to investigate the sign of relationship. Among others, works by Alesina and Rodrik (1994), Persson and Tabellini (1994), Perotti (1996) and Deininger and Squire (1998) are worthy of mention. Due in part to the improved availability of panel data, a large proportion of more recent studies also make use of this type of data,[16] for example studies by Li and Zou (1998), Forbes (2000) and Barro (2000).[17] Also notable are papers that emphasise a specific aspect of analysis, pointing to the greater complexity of the relationship suggested in the theoretical models and with the aim of capturing that complexity. In this regard, Voitchovsky (2005) studies the effect of inequality on growth depending on the distribution quintile in which it occurs, finding that the effect is positive at the top end of income distribution but negative for lower part. Halter et al. (2014) differentiates between effects that occur in the short term, which are beneficial for growth, and those that operate in the long term, which have the opposite effect. Banerjee and Duflo (2003) investigate whether the relationship that occurs between the variables is a linear one, and they find that the imposition of such a relationship is not apparently supported by the data. Castelló-Climent (2010) distinguishes according to the level of development of the region and finds that the effect is negative in middle- and low-income countries[18]. Finally, Brida et al (2020) perform a Granger causality analysis between economic growth and inequality for a sample of countries and also obtain that the relationships change with the stage of development.

The second line of research directly relating to our work is that focusing on analysis of how poverty is related to economic growth. As with inequality, there is a large body of theoretical literature that presents different models identifying the potential channels through which this effect could be transmitted. One fundamental thematic line worth highlighting includes works that point to the existence of poverty traps[19]. These are based on the existence of various underlying mechanisms which, on the one hand, prevent part of the population from attaining certain levels of assets and, on the other hand (and fundamentally) reinforce themselves, thus perpetuating the situation. Some of these mechanisms are said to operate through the personal/psychological characteristics of the poorer population, such as having a higher propensity to consume unproductive goods (Banerjee and Mullainathan, 2010), or the need to spend more time on ensuring the satisfaction of basic needs, or greater risk aversion (Shah et al.

[16] In particular, we highlight the influence on the development of the empirical literature of the database published by Deininger and Squire (1996).
[17] More comprehensive literature reviews can be found in Cingano (2014) or Cerra et al. (2021).
[18] Although it is common in this type of empirical exercises to use instrumental variables (IV) and estimators that rely on this type of procedures, Kraay (2015) points out that the weakness of these instruments is often a common problem and may be affecting the results obtained.
[19] See Kraay and McKenzie (2014) for more detailed study.

(2012) and Banerjee (2004), respectively). On the other hand, different mechanisms are based on the existence of resource or credit constraints that result in underinvestment in physical or human capital assets (Banerjee and Newman, 1993). In the most extreme cases, part of a population may suffer from malnutrition, affecting physical and cognitive performance and thus potential economic growth (Dasgupta and Ray, 1986).

As regards empirical research on the relationship between the two variables – in contrast to analytical models – we find a large number of papers that analyse the impact of economic growth on poverty, especially from the perspective of development economics. Some of this work focuses on the relationship between the growth of the lowest incomes within an economy and average growth, generally concluding that the benefit of economic growth reaches the poor as well as the rest of society (Dollar and Kraay, 2002; Dollar et al., 2016). In turn, Adams (2004) and Ravallion and Chen (1997) estimate the growth-poverty elasticity for a selection of developing countries, obtaining an impact range of between 2% and 3%. Others seek to explain the differing magnitudes of effect by looking at the type of growth, mainly through the sectoral composition, or by examining the initial economic conditions. Among others, Loayza and Raddatz (2010) analyse the effect of economic growth on poverty reduction at various levels of disaggregation of production for a group of developing countries. Ferreira et al. (2010) conduct a similar exercise, focusing on Brazil.

Finally, we highlight a less prolific branch of the empirical literature that considers not only the individual links between some of the distributional variables and economic growth, but also possible interactions between these distributional variables. Bluhm et al. (2018) find that the initial level of inequality mitigates the poverty-reducing effect of economic growth for a group of 124 countries. Bergstrom (2020) conducts a similar analysis for a group of 135 countries during the period 1974-2018. Marrero and Servén (2021), for their part, analyse the links between economic growth and inequality and poverty, considering the possibility of indirect effects through the interaction of the latter two[20]. Ravallion (2001) and Fosu (2017) analyse the effects economic growth on poverty reduction and the role of income inequality for a sample of developing countries.

3. Data

The dataset we use to carry out our empirical analysis is drawn from the various releases of cross-sectional microdata from the European Union Survey of Income and Living Conditions (EU-SILC) over the period 2003-2019[21], which is the maximum length allowed by this official dataset.

[20] See Figure 2.2 for a prior theoretical insight on the links between variables.

[21] Although the 2021 survey referring to 2020 income data was available at the date of completion of this paper, the authors have preferred to exclude it from the analysis due to the distortion of the *COVID-19*

The survey is carried out annually and contains, among other things, data on income (at both individual and aggregate household levels) as well as on demographic and social characteristics of households. It is designed as a rotating panel survey, whereby the same household is followed for four consecutive years, with 25% of the sample being renewed each year. Currently, the EU-SILC minimum sample size is approximately 130.000 households and 270.000 individuals for cross-sectional data.

The decision to use microdata for the computation of our indices, and thus not rely on already published statistics[22], allows us to obtain different income definitions and expand our analysis. Thus, following income definitions of Goerlich (2016), we have opted to take gross income as the benchmark definition of income, chiefly because this includes income earned by individuals in the market as well as old-age benefits.[23] Persons receiving such benefits as their main source of income would not be included in the data for market income, which would distort or misrepresent the results obtained in terms of inequality and poverty. Moreover, this strategy allows us to emphasise the role that public intervention has played in changing causal relationships, depending on whether we focus on cash transfers or the direct tax system.

Based on our baseline definition of income, we calculate indicators that allow us to capture the evolution of each of the distributional variables of interest, following the usual standardisations used in the literature. We employ the Gini index as a measure of income inequality and the Anchored Poverty Rate as a measure of monetary poverty. This measure of poverty indicates the percentage of the population below a certain threshold or poverty line, defined as 60% of the national median equivalized household income in each country. It is therefore a measure of relative poverty and, in this analysis, we have opted to consider 2006 as our anchored reference year, this being the first year for which observations are available for all the countries in the sample. Although it is common in this sort of empirical exercise to adopt an absolute measure of poverty, the rationale behind our choice is that poverty is a phenomenon dependent on the social environment.

The observational unit for computation of the index is the household, as we believe that the main decisions regarding income and expenditure are generally taken at that level, and because this unit allows us to exploit all sources of income collected at household level without having to make assumptions around how these are distributed. Income variables have been adjusted for differences in household size and composition using the OECD equivalence scale. In addition, all

impact on the variables of interest. The causal graphs for the period including 2020 income data can be found in the appendix.

[22] Atkinson and Brandolini (2001) point out the potential comparability problems that often arise in such studies when using less consistent databases. Galbraith and Kum (2005) point out the shortcomings of the Deininger and Squire (1996) "high-quality" data set.

[23] In addition to other income benefits.

indices are obtained using the sampling weights provided by Eurostat. Finally, as a measure of economic growth, we have obtained the rate of real GDP per capita growth from Eurostat.

To sum up, from the calculation of these indices for each country, we have constructed the panel data to be used in empirical analysis. This is an annual frequency panel with 487 year/country observations for the variables of economic growth, income inequality and monetary poverty for 30 European economies over the period 2003-2019.[24]-[25] Of the EU member states, 26 are included, along with Switzerland, Iceland, Norway and the United Kingdom. The choice of period has moved us to disregard data for Serbia and Croatia, as the length of their series is significantly shorter.

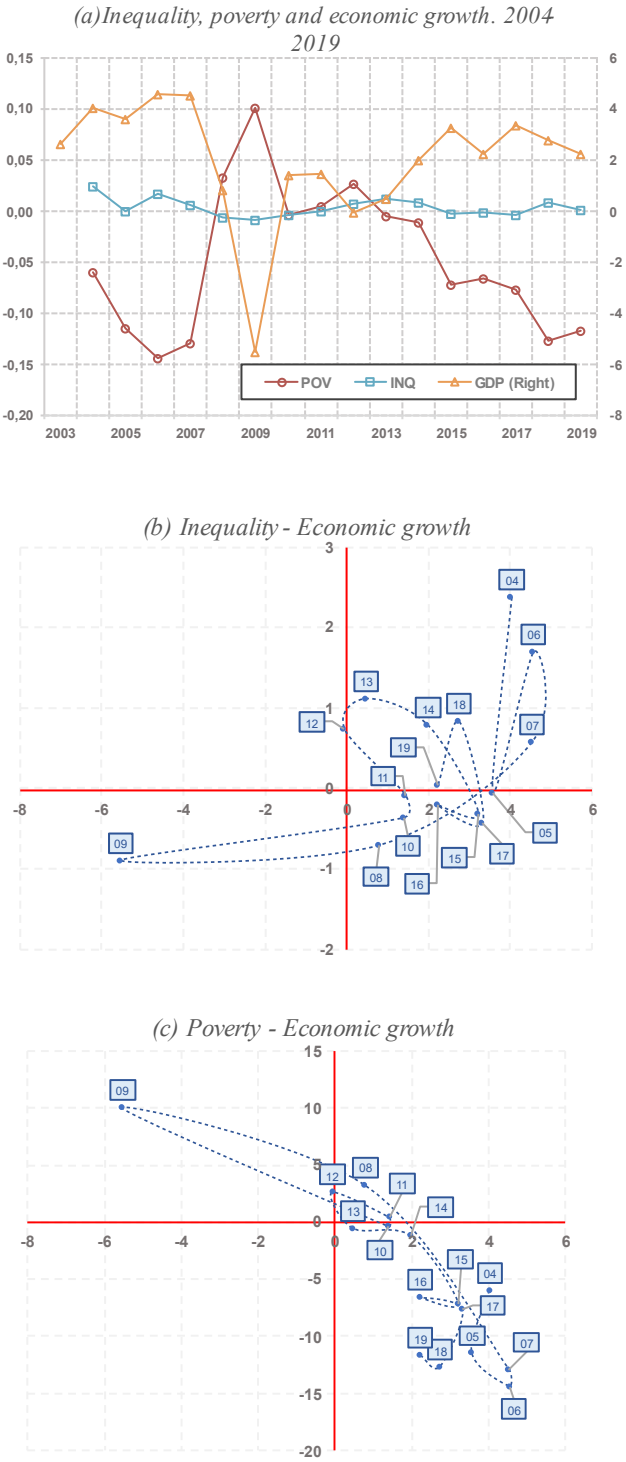
3.1 Descriptive comparative analysis

Top panel of Figure 2.1 shows the evolution over time of the variation rate of the average value of the three variables of interest (Inequality, Poverty and Economic Growth) for the period 2003-2019. It can be noted that inequality shows a less volatile evolution, in contrast to poverty, which evolves in almost the opposite way but contemporaneously to economic growth. Bottom panels of Figure 2.1 show the relationship between both distributive variables and economic growth. It can be noted that, while poverty tends to show a clear countercyclical behaviour, the opposite is true for inequality. In both cases, the values for 2010 seem to show a strongly differentiated performance.

[24] The length of the series is not the same for all countries included in the sample, so we are working on an unbalanced panel.

[25] It should be noted that the year of reference in our analysis is the income year and not the survey year, as collected in the survey refer to the period prior to the year of publication.

Figure 2.1: Recent developments of Baseline model variables, 2003-2019.



Source: Own elaboration from EUSILC data.

4. Methodology

We carry on an ultimate causality analysis based on the approach proposed on Chapter 1. The benchmark specification is a multivariate vector autoregressive panel model (P-VAR) which can be written as:

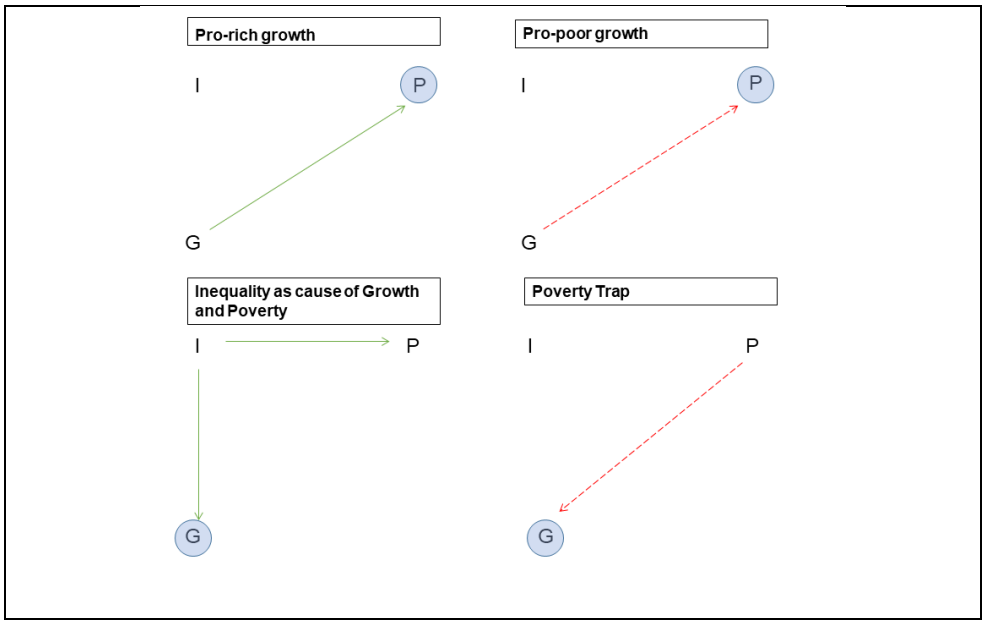
$$Y_{it} = \mu i + \Phi(L)Y_{it-1} + \varepsilon_{it} \quad i = 1, \dots, N;\ t = 1, \dots, T \tag{1}$$

Where Y_{it} is the vector of endogenous variables of a country *i* in a year *t*. This is, economic growth rate, income inequality and poverty rate respectively.

On this basis, we can depart from some theoretical priors that we may later find in our estimations. Thus, Figure 2.2 presents four hypothetical situations in relation to our question of concern. Top panels represent pro-poor/pro-rich literature, as the increasing/decreasing of poverty is caused by economic growth. Bottom left panel represents a situation where inequality is enhancing economic growth but also a poorer society. In this case, the omission or inclusion of this variable (inequality) in the estimation would determine the final results obtained. Finally, bottom right panel represents the poverty trap, a situation where poverty is causing a decrease in economic growth, which may be reinforcing the poverty.

The empirical strategy adopted consists of the following stages: (i) Causal analysis based on Granger (1969) Causality test for panel data followed by the application of the causal search algorithm and obtention of undirected causal graphs. (ii) Determination of the direction of the edges of the causal graphs, based on the CCFs, which would indicate both intensity and sense of the causality. To do so, we follow David (1949), who proposes to obtain an overall measure of dominant correlation based on individual correlation coefficients.

Figure 2.2 Some theoretical model on the basis of *Causal Maps* literature.



Source. Own elaboration.

As mentioned above, to test the existence of a causal relationship between variables we follow Emirmahmutoglu and Kose (2011) and Dumitrescu and Hurlin (2012) who propose calculating a synthetic aggregate from individual measures that allows us to determine the existence of causality between variables for the total sample or any subgroup of cross-section units. Thus, in the case of Granger non-causality, the null hypothesis for the *i-th* individual is defined as:

$$H_0 : \Phi_i = 0 \text{ for all } i. \tag{2}$$

The following transformation of the individual p-values (p_i) is carried out:

$$\lambda = -2 \sum \ln p_i \tag{3}$$

Finally, we proceed to obtain the causal graph along with the application of the PC algorithm[26] in its stable version (Colombo and Maathuis, 2014) to clarify the genuine flow of causality in case the results obtained are inconsistent or admit different interpretations. One of the advantages of causal maps is that we can combine the possible existence of a causal relationship (which does not indicate, in principle, whether the relationship is inverse or direct) with some complementary measure that collects this information within the same graph. So, with both the statistics described in (i) and (ii), we can establish the existence of a causal relationship and the sense and intensity of these relationship.

[26] For a more detailed review of the implementation and application of the algorithm, see Spirtes et al. (2000), Pearl (2000), Colombo and Maathuis (2014) and Le et al. (2016).

5. Results

Table 2.1 provides a detailed overview of the co-movement (CCF) between the different pairs of variables for the aggregate of the whole panel and for each of the countries included in our sample for the period 2003-2019. According to the literature, the two variables are said to move in the same direction if the maximum value in absolute terms of the estimated correlation coefficient is positive, that they co-move in opposite directions if it is negative, and that they do not co-move if it is close to zero. Thus, we take maximum values of the combined correlations in the ranges 0.20–0.39 and 0.40–0.49 as evidence of weak and moderate correlation, respectively. We refer to 'strong correlation' if in absolute terms it is larger than or equal to 0.50 and to 'no correlation' if it is lower than 0.19.

If we consider gross income, which as mentioned in the Introduction will be our benchmark definition of income, we obtain the following: at a first level, for the aggregate of the total sample (ALL), the correlation between the different pairs of variables, although positive in all cases, only exceeds the threshold of 0.2 for the relationship between the inequality and poverty variables. This would indicate that these two variables tend to evolve jointly, albeit with a weak correlation. The rest of the relationships, therefore, do not seem to show a sufficient magnitude to consider some relationship between their movements.

However, once we have looked at countries individually, we see that the situation is very different, characterised by a marked heterogeneity in both intensity and sign. Thus, for Belgium, Czech Republic, Finland and Latvia the correlation is strong and positive for the relationship between Economic Growth and Inequality whereas is strong and negative for Cyprus and moderate and negative for Island, Slovenia, Austria or Switzerland. For the relationship between Economic Growth and Poverty, we can observe that Spain, Hungary and Netherlands present a strong positive link and that Iceland and Greece present a strong negative relationship. Finally, if we focus on the relationship between poverty, we can observe that is strong and positive for many countries (10 of the total sample) and the coefficient is larger than 0.2 for 18 countries. At the same time, we can observe that, for the case of Iceland, all the relationship found are negative and range between moderate and strong correlation. On the contrary, Netherlands presents only positive and strong/moderate coefficients. Thus, we can see a demonstration of the heterogeneity of the results obtained.

Table 2.1 Cross-Correlation among inequality, poverty and economic growth

Country	GDP, INQ	GDP, POV	INQ, POV
Austria	-0.51	0.31	-0.28
Belgium	0.61	0.23	0.58
Bulgaria	0.35	0.41	-0.82
Switzerland	-0.52	0.36	0.32
Cyprus	-0.64	0.53	0.88
Czech Republic	0.66	0.55	0.86
Germany	-0.15	-0.12	0.30
Denmark	0.13	-0.27	-0.87
Estonia	0.37	0.45	0.75
Greece	-0.36	-0.76	-0.38
Spain	-0.3	0.69	0.46
Finland	0.64	0.34	0.20
France	-0.07	0.35	-0.51
Hungary	0.55	0.63	-0.32
Ireland	0.46	-0.34	0.43
Island	-0.44	-0.69	-0.54
Italy	0.39	0.33	0.40
Lithuania	0.26	0.47	-0.27
Luxembourg	-0.22	-0.43	0.48
Latvia	0.72	0.14	0.48
Malta	0.32	-0.40	-0.57
Netherlands	0.57	0.66	0.6
Norway	0.56	0.41	0.66
Poland	0.18	0.15	0.92
Portugal	-0.31	-0.57	0.87
Romania	0.5	-0.26	-0.46
Sweden	-0.38	-0.35	-0.30
Slovenia	-0.53	0.36	0.78
Slovak Republic	0.38	0.53	0.77
United Kingdom	-0.23	-0.54	-0.43
ALL	**0.12**	**0.11**	**0.23**

Notes: ALL denotes the aggregate level of the data used.

The second part of our empirical strategy is to complement the preliminary analysis of co-movement between variables by assessing the significance of various causality tests[27]. Table 2.2 shows the p-values of our causality path, sequenced by levels according to the iterative process -PC algorithm- attending to all possible links amongst the variables selected. As stated on Section 4, in level 1 we begin with bivariate unconditional analysis. For those pairs of variables whose link is significant (a p-value below to 0.1 is found), the test is repeated by subsequently adding the rest of variables to the control set. Pairs at level 1 where the p-value is above 0.1 are excluded

[27] In this sense, we have presented in Tables A2.1 (see Appendix) the results of individual and aggregated p-values obtained for the Granger causality tests, for level 1 and 2.

from the following level. In our case, the final level would be level 2, as we only consider 3 variables.

Hence, we can observe that, for the aggregate of the total sample, the relationships between poverty and growth and between poverty and inequality are significant in both directions, while we do not find evidence of a relationship between economic growth and inequality.[28] At first, this would seem to indicate that poverty plays a leading role in shaping the dynamics between the variables. However, taking into account previous results, although the relationship between poverty and growth is significant, the coefficient obtained for the CFF indicates that the magnitude of the effect is small, and it could be considered extremely weak. In Level 2, after debugging the relationships by applying the PC algorithm, we observe that, among the relationships that were initially significant, three of them survive, thus disappearing the effect of poverty on growth. Hence, we find the previous double causality between the distributional variables of poverty and inequality remains, plus an extremely weak effect of economic growth on poverty.

In this sense, Figure 2.3 shows the causal graphs of the analysis, which combine both the information of the regression estimates and the dominant correlation analysis, and graphically represents the dynamics between the different variables. Thus, when an arrow is found, it means that the relationship between variables is significant, and the colour of the arrows indicates the sing and the sense of the dominant correlation.

Table 2.2 PC algorithm results

Level	Causality from	POV	GDP	Causality from	INQ	POV	Causality from	INQ	GDP
1	INQ→	0.014	***0.35***	GDP →	***0.272***	0.036	POV →	0.000	0.005
2	$INQ\|_{POV}$ →	----		$GDP\|_{INQ}$ →	----	0.078	$POV\|_{INQ}$ →	----	***0.100***
	$INQ\|_{GDP}$ →	0.018	----	$GDP\|_{POV}$ →		----	$POV\|_{GDP}$ →		----

Notes:
1) INQ= Gini Index, Pov= Anchored Poverty Rate, GDP=Gross Domestic Product.
2) Bold and italics denote non-significance at 10% level.
3) All Level 2 models included the full set of endogenous variables when computing the Granger causality test.

At first glance, at level 1 (left panel), we can observe that poverty plays a role as a common cause between inequality and economic growth. At the same time, poverty also acts as an unshielded collider of inequality and economic growth. Therefore, at level 1, it is not possible to disentangle the causality pathway between the variables, with poverty both being *causing* and *caused by* the two remaining variables. In the final map, which is level 2 (right panel) we can observe a slightly

[28] This would indicate that there is no evidence of significance in the relationship between these variables in most countries, although this relationship may be significant for specific countries, as in the case of Switzerland, Ireland or Iceland (see Table A2.1 and A2.2).

different scenario, where poverty is no longer a common cause between inequality and economic growth but keep its role as an unshielded collider. This allows us to disentangle the dynamics as follows: first, economic growth acts as a catalyst, causing poverty. At the same time, both poverty and economic inequality share a common trend that results in a reciprocal relationship between them. These results support the hypothesis of the pro-rich growth literature, where economic growth is not equally distributed among the population, which is translated into an increased in poverty. Such increase is followed by an increase in inequality, which begins the *vicious cycle* between both distributional variables. Furthermore, it highlights the relevance of our methodology in resolving and clarifying potential incongruous relationships between variables.[29]

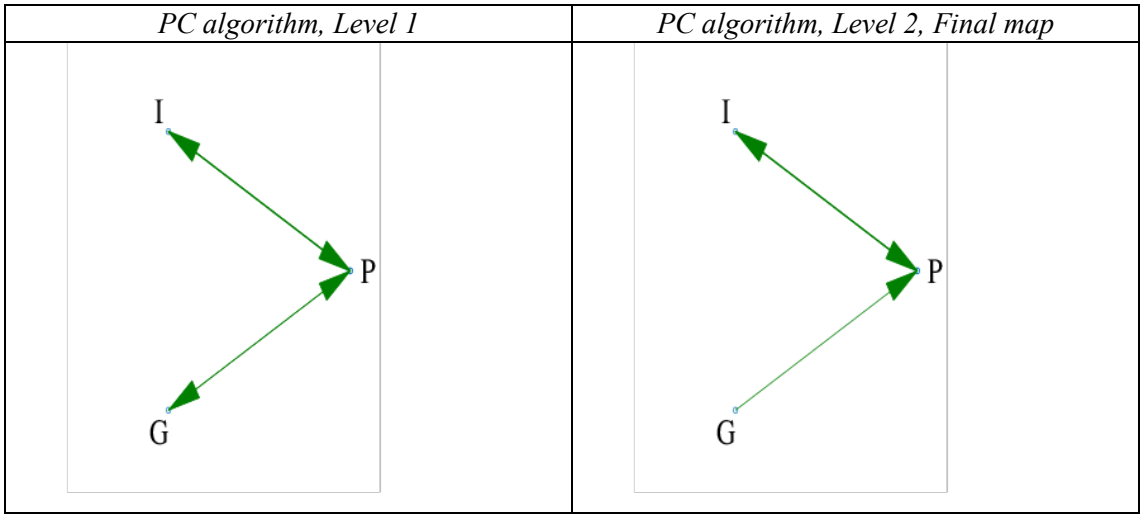
From these results, we draw two main conclusions: firstly, over the period studied, economic growth was not an effective tool for reducing inequality and poverty in the short term in the economies analysed as a whole; secondly, the findings oppose the hypothesis of economic growth following a vertical flow from the rich to the poor. This is congruent with the evolution of the variables described in Section 3, where we found that, despite different periods of economic growth, these had not translated into an improvement in distributional indicators. In addition, the double causality between distributional variables may be making more difficult a reversal of the general worsening trends observed in poverty and inequality.

In Table A2.1 and A2.2 we have graphically shown the individual results of the analysis (p-values) for the countries in our sample together with the synthetic measure of the whole panel (all). However, the relevance of our results is not to identify a specific causal model that is supported by one of the previous theoretical paradigms, but rather to point out the high degree of heterogeneity in the country-specific results and the need of revising analytical and methodological assumptions included in those paradigms as the data-driven evidence do not align with them. On the one hand, we observe that depending on the specific countries we look at, we find different causal relationships between the variables. Thus, we can highlight, among others, the case of France, Malta, Portugal, and Slovakia, in which inequality has a significant effect on poverty, as opposed to. Spain or Netherlands, in which we find that it is economic growth what has a significant effect on poverty that extends from poverty to inequality (See Table A2.1 and A2.2). On the other hand, Table A2.3 and A2.4 shows the causal maps for two robustness analyses in which we consider other definitions of incomes, and alternative sample periods including and excluding year 2020 respectively. Particularly interesting is the case of *market income,* where the dynamic is led by inequality, which has a positive effect on poverty. This effect on poverty is later translated into a negative impact in economic growth. Therefore, the differences found when

[29] In the specialized literature, there are different definitions of pro-rich growth. In this article, the term is used to describe a situation in which those with higher incomes benefit to a greater extent from economic growth.

moving from market to gross income, may be indicating the powerful role played by cash transfers in avoiding the negative effects found of poverty on economic growth at market income. Moreover, the shift from market income to gross income scenario can be interpreted as a signal that government are more inclined to adopt policies that promote efficiency rather than equity.

Figure 2.3 Path obtained for a selection of conditional bilateral relationships.



Source: Own elaboration using Causality Map Toolbox.
Notes:
1) I= Gini Index, P= Anchored Poverty Rate, G=Gross Domestic Product.
2) Granger's Causality test obtained at 10% of significance level for 2003-2019. The solid (dashed) line indicates that the crossed correlation between each pair of nodes is positive (negative). Finally, the wider is the line, the higher is this value.

In this sense, one of the fundamental advantages of the methodological approach we adopt in this paper is that it allows us to directly exploit the individual characteristics of each of the countries without losing the objective of trying to establish common patterns or trends. On the one hand, it is unquestionable that public intervention and different Tax- Benefit (TB) systems can be decisive in the final configuration of these relationships, as the causal path varies completely depending on the income stage considered. As we have shown above, there is empirical support to affirm that its result varies depending on whether we consider its function via expenditure (cash transfers) or when additionally taking into account the effect of the TB system (disposable income). This in turn offers a clue as to the importance of focusing on dynamic analysis, since throughout the period analysed, the trends in transfers and revenue collection were very different and were strongly influenced by the evolution of the economic cycle.

Our results also indicate that attempting to impose an *a priori* causal structure may be influencing the results obtained in the empirical literature, as we find that the double causality relationship between variables is usually common, and we further observe very diverse causal structures that, to some extent, differ from those established and accepted. Thus, it seems appropriate to be

cautious about imposing common, time-constant models for economies that are different from each other.

6. Concluding remarks

This paper provides novel evidence on the nature of relationships between inequality, poverty and economic growth in Europe. We carry out a dynamic Granger causality analysis between the three variables for 30 European economies over the period 2003-2019 with the main objective of analysing the existence of a relationship between our variables of interest for the common geographical area. For this purpose, we use an annual frequency database constructed from EU-SILC micro-data. Our analysis is based on a VAR model for panel data, where we compute different synthetic estimators from the individual statistics. Complementarily, we apply a causal search algorithm that allows us to debug possible incongruent relationships (the PC algorithm) and interpret our results according to the causal graph literature.

Our estimates indicates that for Europe, there is a positive effect from economic growth to poverty. At the same time, the interaction between inequality and poverty plays a key role in shaping the evolution of the distributional dynamics, creating a *vicious-reinforced cycle* between both of them. Moreover, we also find that economic growth does not affect the evolution of any of the distributional variables, not alleviating poverty or inequality.

On the one hand, those results are aligned generally aligned with the results of the *pro-rich* growth literature, where the poorer household do not equally benefit of economic growth. In this sense, the positive effect of inequality on poverty amplifies the increase of poverty derived from economic growth. More concretely, our results are also aligned with Michálek and Výbošťok (2019), who find that for a set of European countries, the positive effects of economic growth on poverty are offset by an increase in inequality, with a final effect of poverty increases. Similarly, Mussida and Sciulli (2022) find that in general the policies aimed to alleviate poverty on Europe during 2005-2018 were not successful on breaking poverty cycles. However, our work aims to go beyond, seeking to explore the causal dynamics not only between poverty and economic growth, but also the relationship of both with income inequality. This is accomplished through a methodology that refrains from opting, a priori, for a specific directional sense of these relationships.

On the other hand, when broadening the analysis to other income definitions, we found that the effects between inequality and poverty are found in all the scenarios. However, when focusing on market income, a negative effect of poverty on economic growth is found, whereas a double causality between inequality and poverty and between economic growth and poverty is found. This may be due to the different distributive effects generated by the public tax and benefit

systems of each country on shaping these confronting findings (between those obtained with market income and with disposable income).

Some relevant conclusions can be derived from our results. Firstly, it should be emphasised that economic growth does not seem to show a global reducing effect on inequality or poverty in any income definitions analysed. These results, on the one hand, challenge the hypothesis which argue that higher economic growth will benefit households with fewer resources through indirect effects. Rather, the results show that, in order to reduce poverty and inequality, it is necessary to undertake specific policies and not to rely exclusively on those aimed at enhancing economic growth. Furthermore, for most models, we find evidence of a robust relationship between the two distributional variables, whether through direct or indirect effects. Therefore, it seems necessary to take into account the interaction between these two variables when designing social policies.

Moreover, the analysis at the county level show great heterogeneity on the results, with several implications. This suggests that the design of universalist or generalist economic policy recommendations would be less effective than public policies specifically designed for distinct countries. On the other hand, we also observe that the relationships found in the first income stage (market income) disappear totally or partially as we move the focus of the analysis to income distributions in which the intervention of the public sector is greater – such as gross income, where cash transfers are included, or disposable income, after the application of the direct taxes considered in the analysis. We can conclude that public intervention would be an effective tool to mitigate possible shocks or adverse effects arising from these relationships, both through expenditure and through the tax-benefits system, as far as direct taxation is concerned.

In conclusion, we should emphasise that the main contribution of our work is in the novelty of the dynamic approach adopted, which we believe can serve to complement and enrich debate on the matter. Our methodological approach focuses on causal dynamics, often forgotten in favour of approaches based on comparative statics (in which the relational sequence appears pre-established). We believe that this change of perspective allows us to question certain *a priori* assumptions about the relationships under study. We should also clarify that we approach the study of causal relationships between growth, inequality and poverty from a neutral perspective, exploring all possible causal flows between variables without first imposing a sense of causality. In addition, we analyse jointly the relationships between economic growth and the different distributional variables, which have often been analysed as separate issues.

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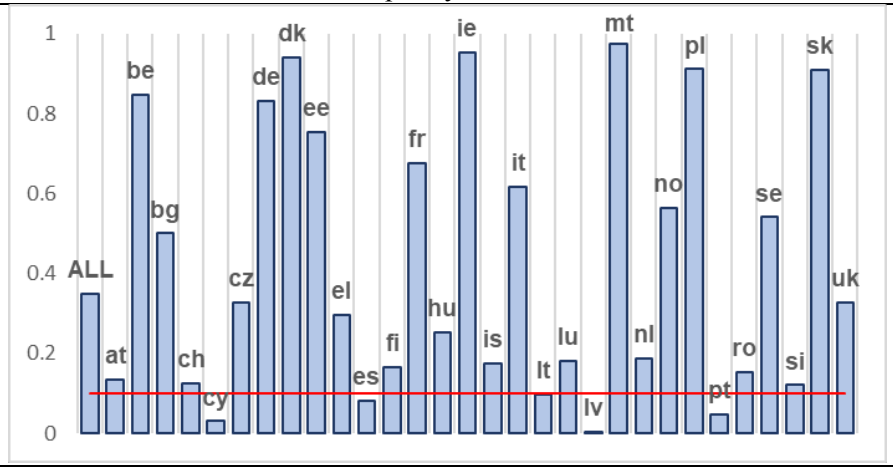
Appendix 2

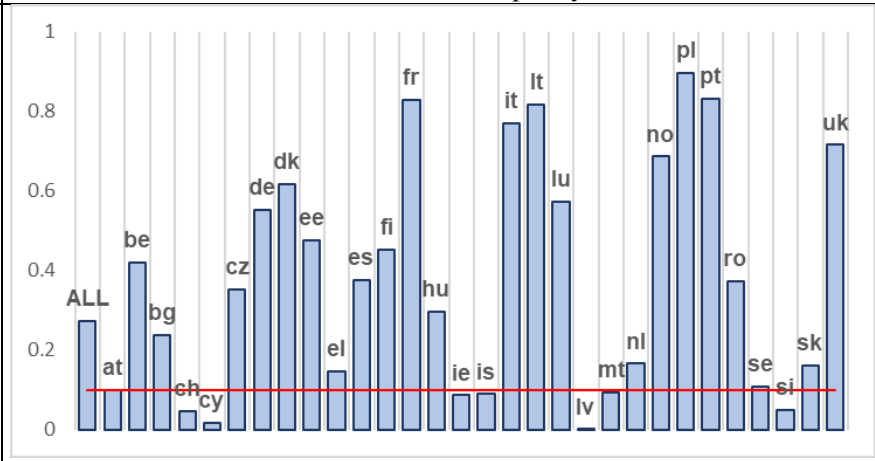
Table A2.1: P-value Significance - L.1 - Model: Gross Income

Bivariate model 1: Inequality and Economic Growth

Inequality to GDP

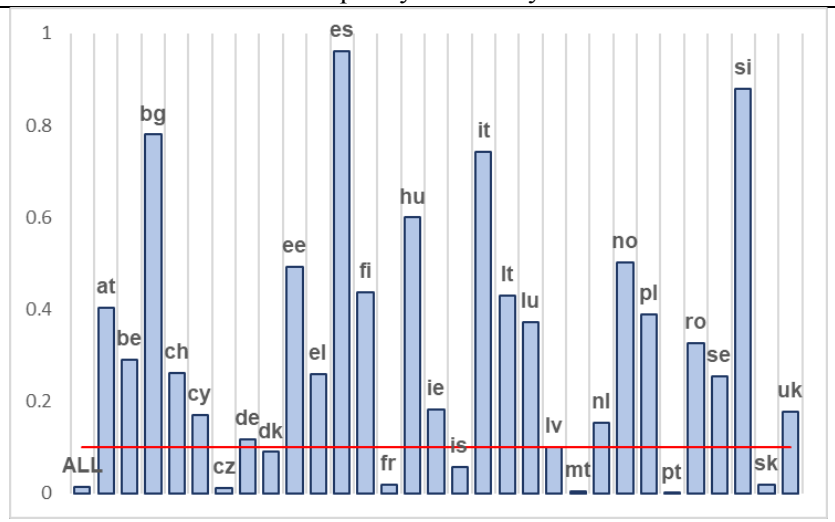


GDP to Inequality

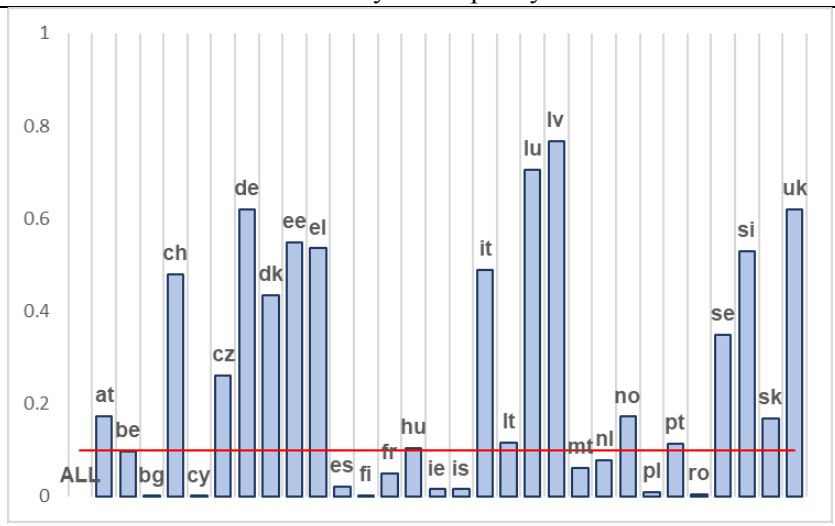


Bivariate model 2: Inequality and Poverty

Inequality to Poverty



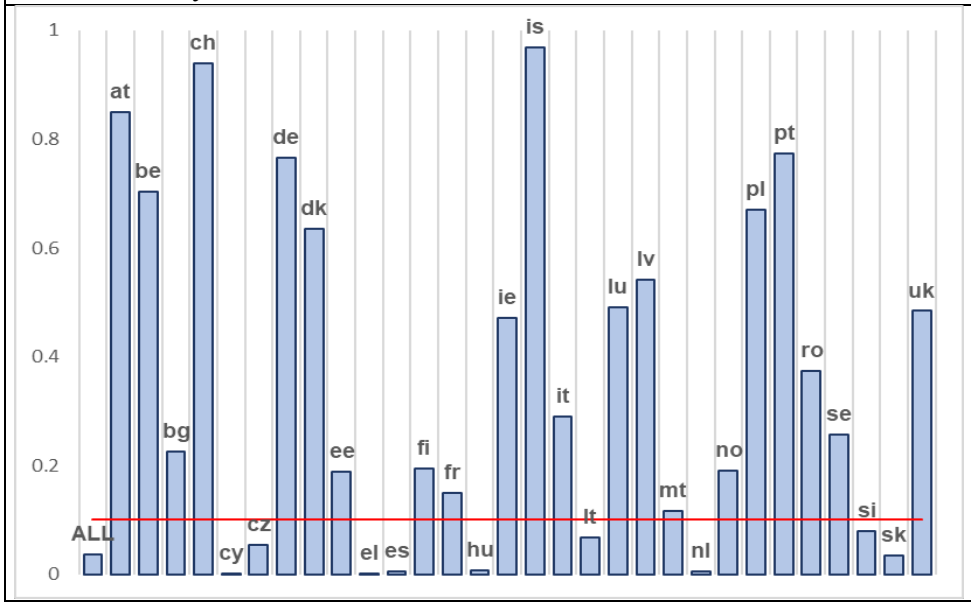
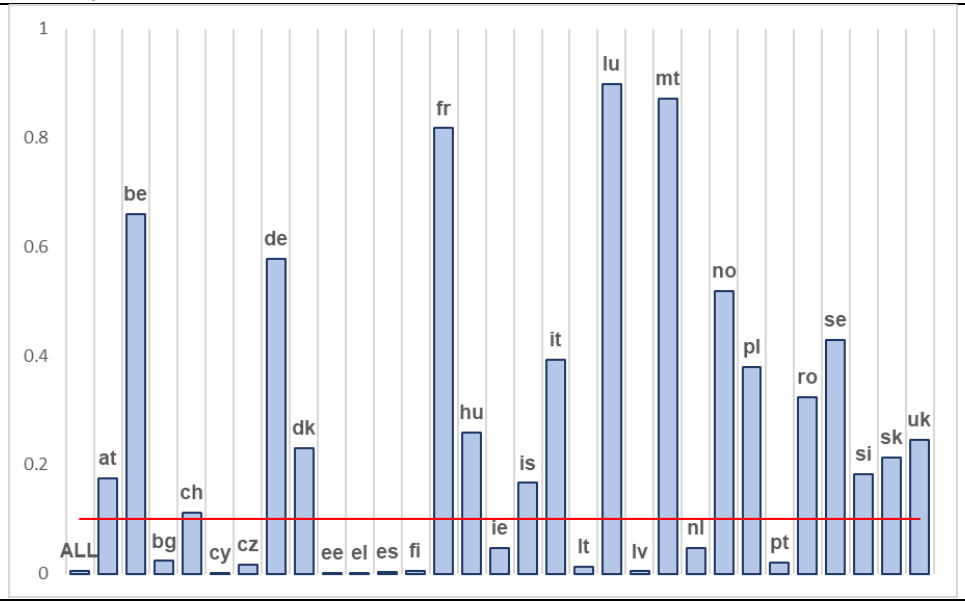
Poverty to Inequality



Source: Own elaboration using Causality Map Toolbox

Notes: (1) Results obtained from Granger's causality test at 10% of significance level, for the period 2003-2019. (2) INQ= Gini Index, POV= Anchored Poverty Rate, GDP=Gross Domestic Product.

Table A2.1(cont.): P-value Significance - L.1 - Model: Gross Income

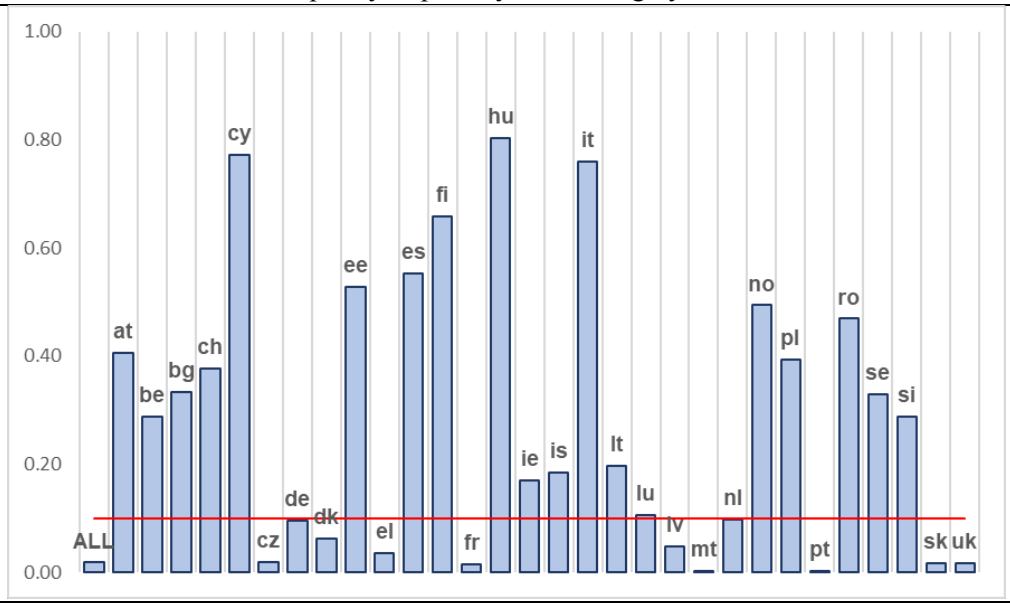
Bivariate model 2: Poverty and Economic Growth	
GDP to Poverty	Poverty to GDP
	

Source: Own elaboration using Causality Map Toolbox

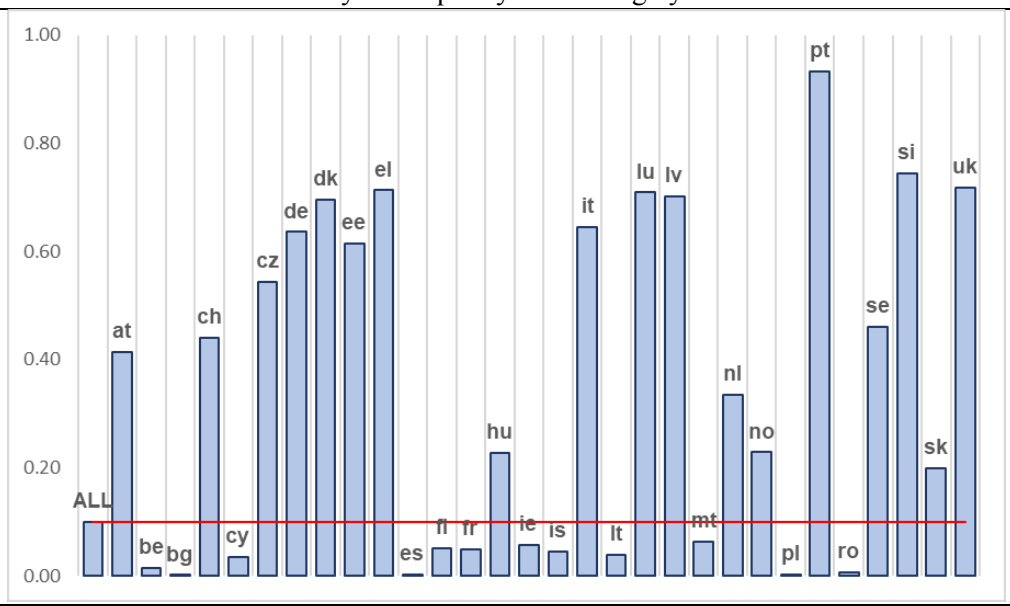
Notes: (1) Results obtained from Granger's causality test at 10% of significance level, for the period 2003-2019. (2) INQ= Gini Index, POV= Anchored Poverty Rate, GDP=Gross Domestic Product.

Table A2.2: P-value Significance - Survival links- Gross Income - Level 2

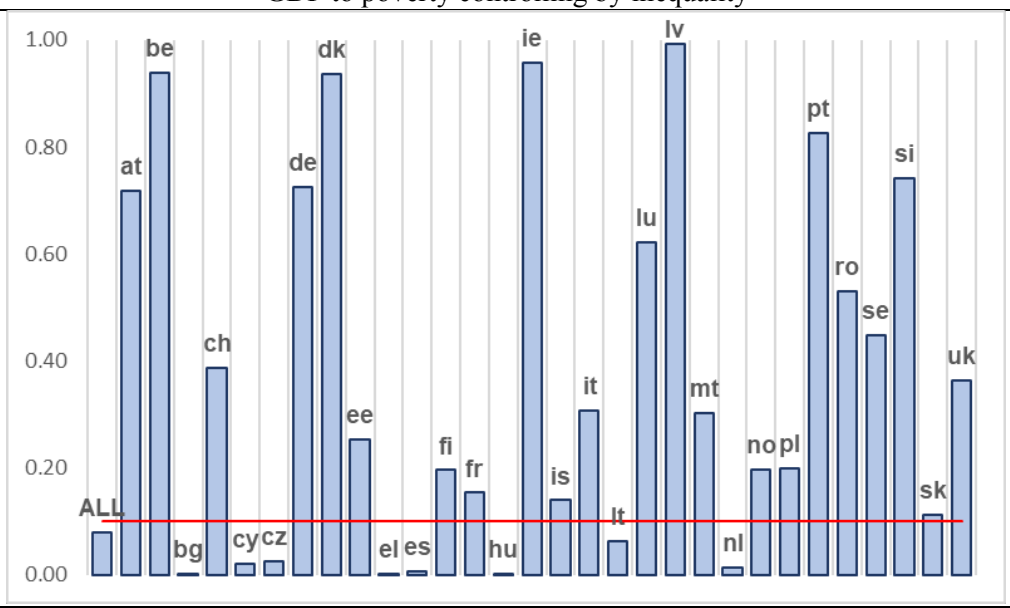
Inequality to poverty controlling by GDP



Poverty to inequality controlling by GDP



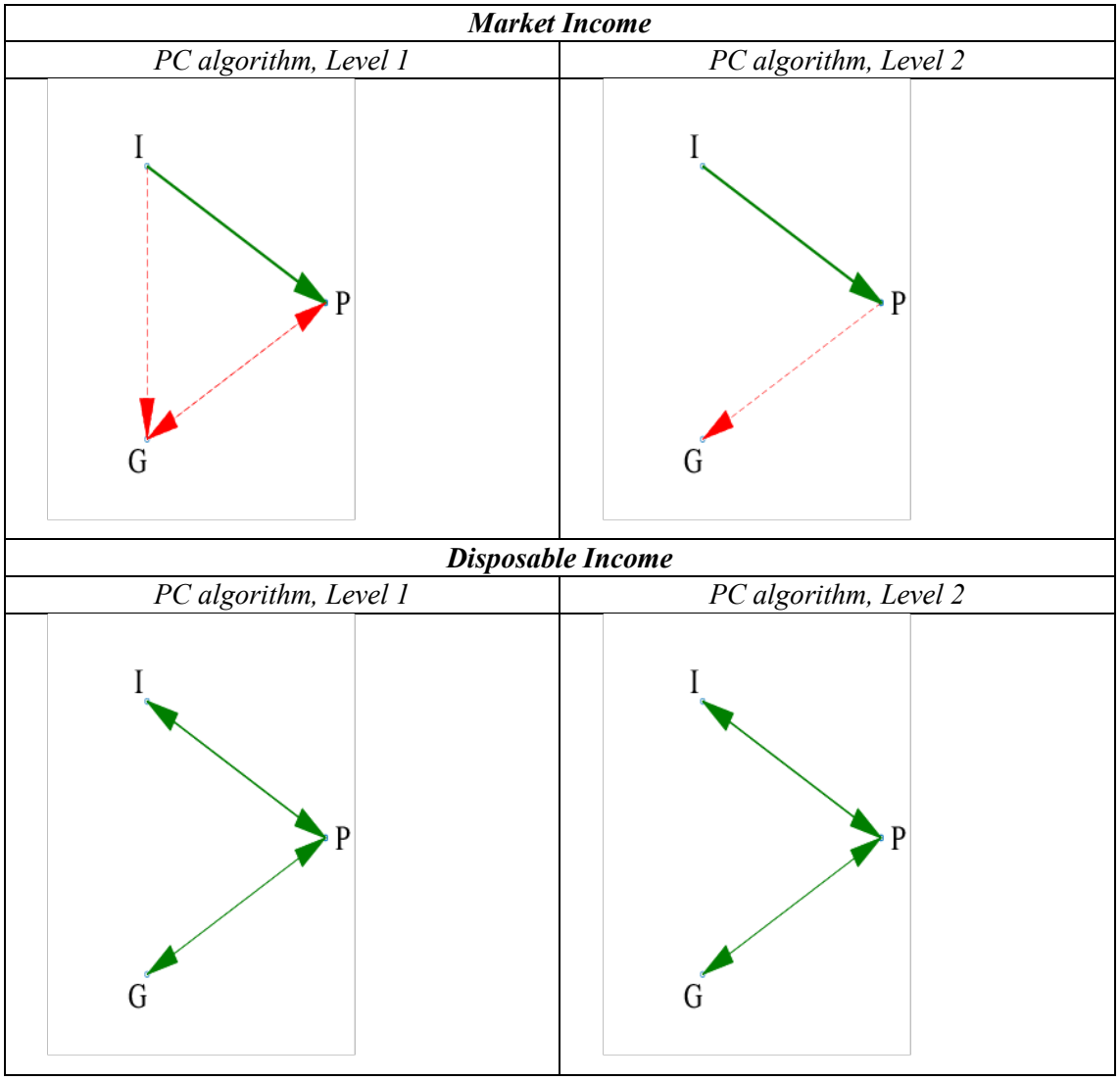
GDP to poverty controlling by inequality



Source: Own elaboration using Causality Map Toolbox

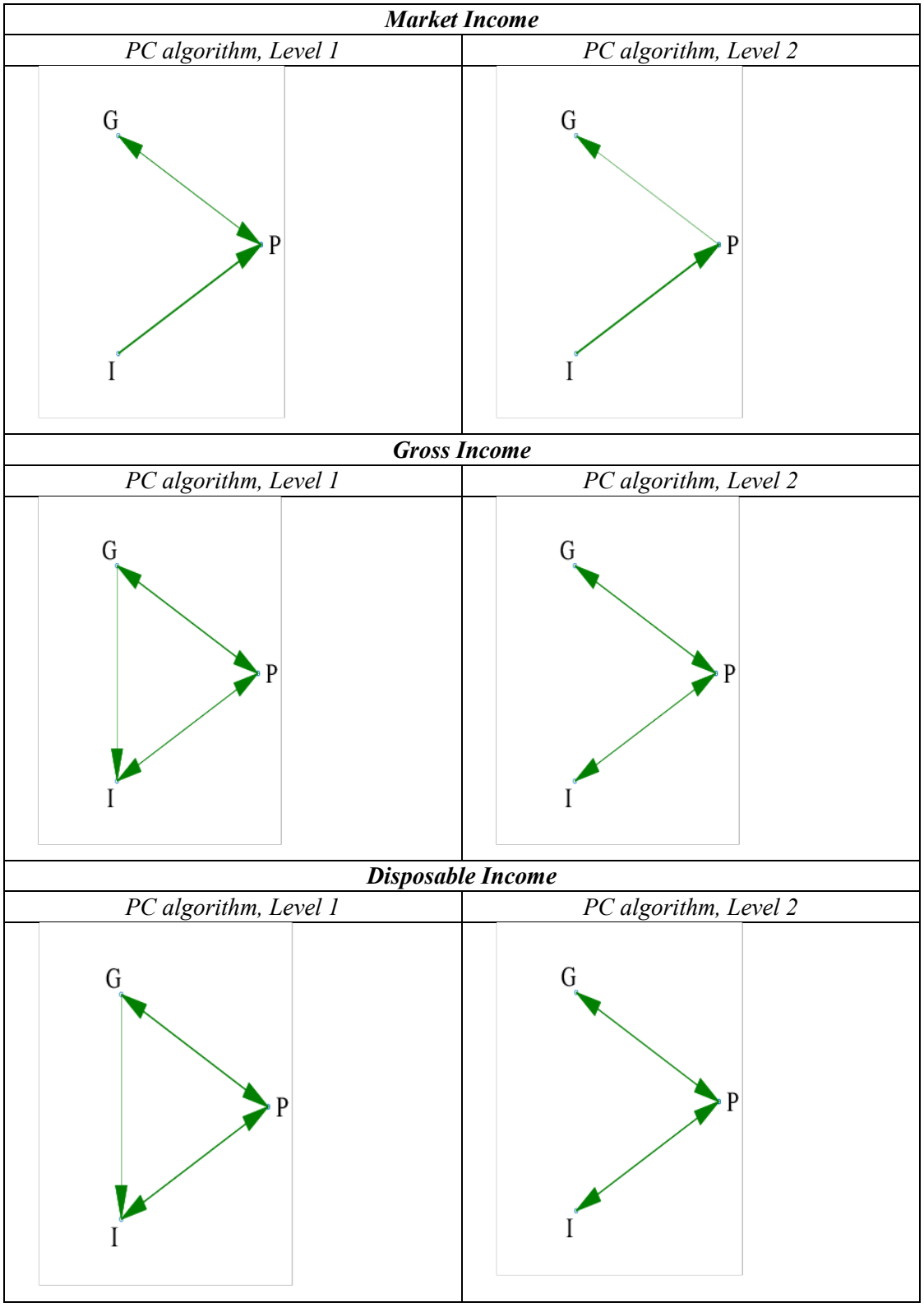
Notes: (1) Results obtained from Granger's causality test at 10% of significance level, for the period 2003-2019.

Figure A3: Path obtained for a selection of conditional bilateral relationship for market and disposable income.



Source: Own elaboration using Causality Map Toolbox.
Notes: 1) I= Gini Index, P= Anchored Poverty Rate, G=Gross Domestic Product.
2) Granger's Causality test obtained at 10% of significance level for 2003-2019. The solid (dashed) line indicates that the crossed correlation between each pair of nodes is positive (negative). Finally, the wider is the line, the higher is this value.

Figure A4: Path obtained for a selection of conditional bilateral relationship for market, gross and disposable income including 2020 data (COVID effects)



Source: Own elaboration using Causality Map Toolbox.
Notes: 1) I= Gini Index, P= Anchored Poverty Rate, G=Gross Domestic Product.
2) Granger's Causality test obtained at 10% of significance level for 2003-2019. The solid (dashed) line indicates that the crossed correlation between each pair of nodes is positive (negative). Finally, the wider is the line, the higher is this value.

Chapter 3

Revisiting traditional Welfare State taxonomies from an unsupervised clustering approach: the case of the European Union countries

Abstract:

The aim of this paper is to revisit some of the well-established Welfare State taxonomies adopting a data-driven approach. Particularly important in the field is the typology of Welfare States proposed by Esping-Andersen (1990), which has served as a basis to numerous works. To fulfil the aim of the paper, we compile a comprehensive list of EUROMOD welfare indicators, specifically those being commonly used in the related literature. Then, we applied *machine-learning* unsupervised cluster techniques to determine the number of groups found and the countries belonging to each group. Previously, when needed, we reduce the dimensionality problem by applying Principal Components Analysis (PCA) techniques to prevent the inclusion of redundant information in the model. Once we have extracted the subjacent trends, unsupervised techniques of clustering are applied to obtain alternatives classifications of Welfare States. In this regard, the contribution of this paper is twofold. First, we broaden the perspective from which Welfare State is quantified by including indicators that encompass simultaneously all its fundamental features. Particularly, following the previous studies, we have selected indicators to quantify the degree of *redistribution*, the *progressivity* of the tax-benefit systems, the *relative weight of each instrument*, and the *poverty reduction* achieved. Second, we obtain for each pair of countries the likelihood of belonging to the same cluster/group, depending on the set of features included.

1. Introduction

In recent decades, one of the most analysed topics has been the study and development of various taxonomies to classify welfare states. One of the most influential contributions has been that of Esping-Andersen (1990), who proposed a classification of three different welfare categories - liberal, conservative and social-democratic- based on the concepts of decommodification and social stratification. This classification becomes the foundation for much of the work in applied comparative economics and it captured and influenced a significant portion of the subsequent debate and work on welfare state taxonomies, whether to reaffirm the validity of the proposed classification or to highlight its limitations and weaknesses.

Most of the contributions to this branch of the literature were made within the perspective of Comparative Political Economy and generally aimed to establish classifications of different welfare regimes based on their institutional design. To this end, most studies used aggregate data and follow what is been called an *input approach.* That is, analysing different aspects of the state resources destinated to cover social risks (welfare policies). These studies have generally focus on aspect such as the size of the public spending (welfare effort) but have also include aspect as policy's generosity or coverage rates.

Less common, and particularly conditioned by the availability of systematically and consistently collected microdata, are studies that, on the contrary, have established different typologies of welfare states based on the *outcome approach*. This approach involves focusing on the degree of achievement of social objectives, rather than on the resources available for them and it has generally focused on analysing differences in the redistributive capacity of different welfare states. In this regard, a large portion of these studies have analysed how inequality and poverty change before and after public intervention, and through which fiscal policy instruments these distributive changes are achieved. Within this analytical framework, most contributions have focused on developing empirical strategies to more precisely identify what proportion of the change can effectively be attributed to each policy instrument.

However, to the best of our knowledge, there has been no study to date aimed at analysing the similarities that arise in *how* these states allocates their resources among the population. That is to say, the purpose of this paper is not to study the degree of redistribution achieved by different countries, but the *way* how this redistribution is achieved by means of the distribution of its fiscal policy instruments among households. In this sense, we believe that the approach adopted here provides a novel perspective and serves as a complement of the aforementioned approaches. In other words, the way these resources are distributed among the population lies between the resources assigned by states to social policies and the objectives they achieve with them.

This paper main concern is about whether the usual welfare taxonomies based on qualitative macro indicators and degrees of redistribution also emerge when analysing empirically how the public sector distribute its resources or, on the contrary, to identify new patterns not directly aligned with the usual classifications can be found. To this purpose, we rely on EUROMOD -the microsimulation model of the EU-microdata output to analyse the structure of fiscal policy and the differences on allocating resources for various European welfare states. Then, to contrast whether indeed common patterns emerge enabling the identification of groups of countries, we adopt a data-driven approach. To this end, we rely on cluster analysis techniques that enable us to study the underlying structure of similarity patterns in our sample of indicators adopting a more neutral or agnostic perspective. Thus, our aim is not to test the existence of groups based on a theoretical foundation but to examine the presence of empirical regularities.

One of the main drawbacks of cluster techniques applied to this topic is that they are dependent of the period used to compute the indicators, since the standard techniques are not usually designed to incorporate a time dimension. To overcome this issue and incorporate potential temporal changes that may occur in the obtained groups, we have adopted the strategy of conducting the analysis independently for each year of the period 2008-2019 and aggregating the results in a second step. This way, we also exploit the potential of the data to reflect changes stemming from the different moments of the economic cycle that occurred during this period to evaluate whether this translated into changes in the welfare regimes previously observed.

The rest of the article is organized as follows. In section two we perform a review of the literature concerning this topic. In section three we describe on detail the data and the methodology used. Section four offers the main results derived from our analysis. Finally, section five concludes.

2. Literature review

The efforts aimed at establishing different classifications for welfare states date back to the 1960s and 1970s. The early works usually focused on analysing differences in the size of the public sector among different states (Wilensky and Lebeaux, 1965; Wilensky, 1975). However, Esping-Andersen's seminal work (1990) marked a turning point in the development of this branch of literature. On the one hand, he argued that the *expenditure approach* could have been producing misleading results, as even countries with the same amount of public spending could have different social priorities. Taking this into account, he developed the concept of *decommodification* and proposed a classification based on it and on social stratification. For this purpose, leveraging both quantitative and qualitative information, two synthetic indices were computed to depict countries' scores on both criteria, and found that, on the 18 OECD countries included, welfare states predominantly took three different forms: liberal, conservative, and social democratic.

Much of the subsequent developments drew upon this taxonomy either to expand it or to present alternative approaches that addressed some of the limitations present in the original work. The most common criticisms foundations can be grouped around the following lines: (i) the limited sample of countries included on the analysis; (ii) the approach adopted or the variables included; (iii) the absence of gender perspective in their analysis; (iv) the methodology applied to address the formation of groups.

Regarding the first criticism, the primary aim has been to broaden the analysis to include more countries with different level of development. Thus, countries from Southern Europe (Leibfried, 1992; Ferrera, 1996; Martin, 1996) or post-communist countries were included founding that they conform, respectively, a different category of welfare state (Castles and Obinger, 2008; Aidukaite, 2009; Piotrowska and Rae, 2018; Lauzadyte-Tutliene, et al., 2018). Yörük et al., (2022) adopt a more comprehensive perspective bringing together developed and developing countries, founding four different welfare categories: institutional, neoliberal, populist and residual. Gough and Abu-Shark (2011) proposes a classification focusing on the sources of public revenues for a broad sample of countries in the global south, excluding OECD countries.

In relation to the second of the criticisms, to address it, primarily two separate lines of debate have been developed, which have conditioned the strategies adopted in these studies. The first line of debate has focused on analysing the issue around the distinction between old social risks and new social risks. Whereas the studies grouped under the first category focused on examining how the state dealt with the fundamental social risks in the societies of the 1980s - generally unemployment, sickness, and retirement - more recent works have chosen to 'update' the risks currently faced by societies. Thus, different studies have chosen to include new variables representative of welfare states that were not typically included in previous related analyses. Among others, these new social risks encompass issues such as gender (Korpi, 2000; Bambra, 2005; Chybalski and Marcinkiewicz; 2021), aging societies, investment in education and human capital (Hudson and Küner, 2010; West and Nikolai , 2013), chronic unemployment problems (Pfeifer, 2012).

The second line of debate moves away from the distinction between old and new social risks to focus on the approach from which the welfare state is measured. As we discussed in the introduction, the two main approaches were the so-called *input approach*, which analyses the resources that states had to face challenges and based on this establish classifications, and the *outcome approach*, which, on the contrary, classified states based on the objectives they achieved. Within the input approach, recent contributions have opted for computing more complex indicators that capture more than one dimension of the Welfare State in a single composite index (Korpi and Palme, 2007; Scruggs, 2007). The most usual dimensions considered are replacement

rates, duration days, qualifying periods and coverage ratios of the main social programmes - unemployment, sickness and old age pensions- which are aggregated on what it has been called "*Generosity Index*" (Scruggs and Allan, 2006).

There are fewer studies that adopt the outcome approach and most of them focus on the degree of redistribution achieved by different states. Mahler and Jesuit (2006) analyse fiscal redistribution on developed countries by distinguishing the role played by transfers and taxes and focus on the efficiency and fiscal effort of the states. Kammer, Niehues and Peischl (2012) revisit the usual Esping-Andersen Welfare typology for 15 European states by applying cluster analysis to a set of distributional measures that capture the overall Welfare State redistribution and the specific role of each instrument. In Fuest, Niehues and Peichl (2010) the authors focus on studying the redistributive role of each instrument and propose to take two different approaches to address it, the standard accounting approach on the one hand and the decomposition approach on the other. Once the relative importance of the instrument has been measured, they analysed the similarities found across Member States of the EU by means of a cluster analysis. Ferragina et al. (2015) analyse whether the different European welfare states differ when reducing inequality and poverty on different social groups.

Finally, Table A3.1 summarizes some of the main references mentioned in this section.

3. Empirical analysis

The empirical analysis consists of two parts. In the first part we present and explain the data and the indicators chosen and perform a descriptive analysis. In the second part we explain the details of the cluster techniques and how they are implemented.

3.1 Data and indicators

Our analysis is based on different indicators calculated from EUROMOD output data. EUROMOD is the tax-benefit microsimulation model of the EU that allows to simulate the total amount of benefits and taxes received and paid by European households accounting for the fiscal policy of each country. It is based on EUSILC microdata, so it ensures comparability and representativeness over time. We have used EUROMOD i5.0+ version[30] and we have analysed data for the period 2008-2019.[31]

The more common approach when analysing the effect of fiscal policy instruments from a welfare perspective usually implies to differentiate between taxes, social insurance contributions, pension

[30] This version was the last available on the moment of writing this paper.
[31] Although EUROMOD offers the possibility to extend the period until 2023, we have chosen to only include until the last available data before COVID to prevent the analysis from being influenced by the effects derived from it, as it goes beyond the scope of the paper.

and other benefits, the latter as a single category. However, one on the main advantages of using EUROMOD as microsimulation model is that allows to disaggregate benefits to a greater degree of detail. So, this enables us to calculate for each household, the total benefits[32] received and classify them into the next four categories[33]: (a) pension[34] (other than old age's) and health benefits; (b) family and education benefits; (c) social assistance and housing benefits; and finally, (d) unemployment benefits. In this regard, pension and health category includes survivor benefits, health related benefits and disability benefits. Family and educational category includes family related benefits and education related benefits. Social assistance and housing category includes social assistance benefits and housing benefits. Finally, unemployment category includes unemployment benefits, unemployment assistance, family supplement, unemployment benefits for training and other unemployment benefits[35,36.] Using these categories as a reference allows us to gain a more comprehensive understanding of the orientation of benefits within the welfare states of the EU and how they are implemented.

The main objective of this paper is to focus on the (dis)similarities of how the states distribute their resources among households. For this purpose, we adopt a sufficiently broad perspective in the selection of indicators to capture all possible differences, including not only a microeconomic but also a macro perspective. We rely on the following indicators, based on the classification of benefit explained above[37]:

a) Extent of redistribution by quintile: The proportion of the total amount of benefits that are perceived by each quintile.
b) Benefit composition: the benefit mix (proportion that every kind of benefits represent over the total amount of benefit). This is calculated for the whole distribution as well as for every quintile.
c) Progressivity of instruments: we include the Kakwani index of every kind of benefit as well as the of taxes and social contributions.
d) The relative weight of the different instrument over disposable income and market income.
e) Redistribution achieved by each instrument: we include indicators of redistribution from various approaches.

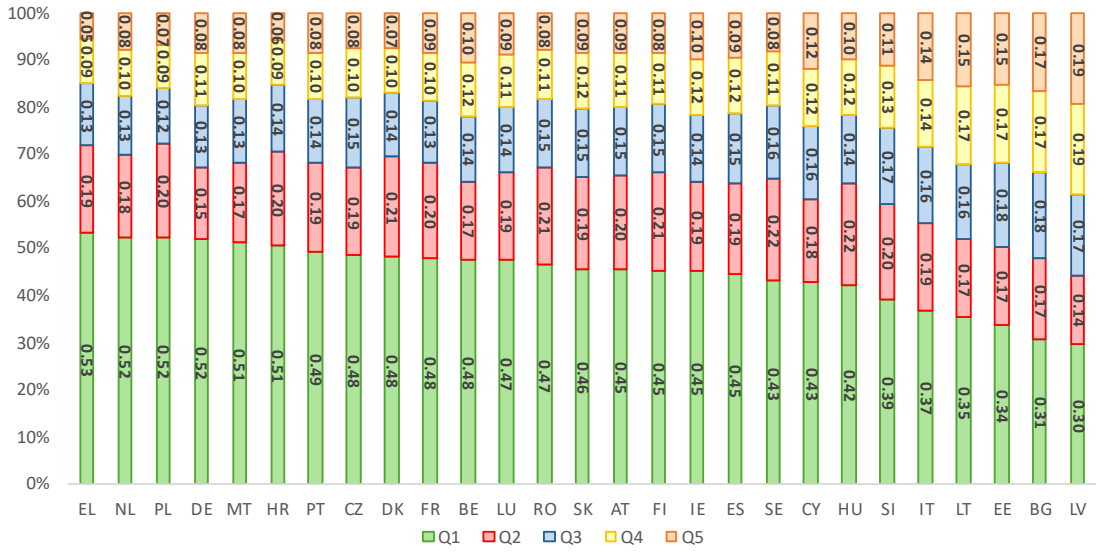
[32] As a microsimulation model, EUROMOD allows to make assumption over the non-take-up of benefits. The default adjustments have not been modified as it goes beyond the objective of the paper.
[33] These categories are computed within the model itself, so this categorization aligns with the EU approach of categorisation.
[34] In our analysis, old age pension has been treated as market income, so this category includes survivors, disability and health benefits.
[35] Not all countries have all the unemployment related benefits. It will depend on their national legislation.
[36] The sum of the benefits included in these categories constitutes the total benefits received by each household.
[37] For a complete list of indicators and their formula see Table A3.2 in the appendix.

f) Poverty alleviation achieved by each instrument: we include indicators of poverty alleviation form various approaches.

To be able to explore the data before conducting the cluster analysis, we have pooled the indicators for the period 2008-2019 and selected a subgroup of the more relevant. By doing so, we shape our expectations and hypotheses about the potential results we will obtain later on in the cluster analysis.

In this section we examine the pattern of distribution of public resources achieved by the welfare states. Figure 3.1 illustrate the share of total benefits that is directly received by each quintile. At first glance, we can observe that in all European states, the Q1 is the segment of the population that receives most of the resources. However, significant geographical variations are also evident. While in countries where more resources are directed to the poorest households (Greece, Netherland, Poland and Germany) -the first quintile receives around 53% of the total benefits- we observe that this amount decreases to 30% in those with fewer resources. On the other hand, significant differences also occur in the amount of resources received by the richest households, specifically those belonging to Q4 and Q5. Generally, between both groups, they tend to receive roughly 20% of total public benefit. This is not the case, however, in Italy and Eastern European countries, where the richest segments of the population receive between 30 and 40% of the resources, approximately. The most extreme case is Latvia, where households belonging to Q4 and Q5 receive slightly more resources than those belonging to Q2 and Q3.

Figure 3.1 Extend of redistribution by quintile (%)



Source: own elaboration based on EUROMOD output. Country average data for period 2008-2019

However, this information isolated is not enough to form an accurate understanding of the similarities between welfare states, as the identical percentage of benefits allocated to different population segments may entail diverse expenditure needs. For instance, in countries with high unemployment rates increases during the Great Recession, like Greece, these benefits may predominantly comprise unemployment benefits, whereas in countries with a greater emphasis on familial support, such benefits may constitute a larger proportion. Hence, in Figure 3.2, we have disaggregated the mix of benefits received by each quintile.

In Figure 3.2, the following can be observed. In Romania, Hungary and Bulgaria, family benefits carry the greatest weight in the total benefits received by the poorest households, whereas in countries like Denmark, Luxembourg, France, Sweeden, Netherland, Austria, social assistance and housing benefits have the greatest importance. Likewise, in Czech Republic Poland, Estonia, Latvia, Lithuania, Slovenia, Hungary, Portugal, and Italy the poorest households receive, predominantly, benefits corresponding to the category of old age and health. Finally, Spain, Belgium and Germany appear to form a separate group in which unemployment benefits represent the most significant group. Moreover, in the case of Spain, it is noteworthy that social and family benefits each account for only 10% of total household benefits in Q1.

The bottom right panel shows that if we focus on the Q2 household, the geographical difference in terms of the type of benefit that constitutes a larger percentage tends to diminish. In general terms, benefits related to old age and health constitute a larger percentage in virtually all countries except for Hungary, Malta, Sweden and France, where family benefits represent a larger amount, and Germany, Austria, Luxembourg, and Ireland, where the amounts are similar between both groups of benefits However, there are indeed national differences regarding the percentage they represent. Thus, in Croatia, Poland, Italy, Czech Republic, Slovenia, Spain, Slovakia, Lithuania, they represent proportions between 70% and 60%, whereas in Portugal, Greece, Romania, Bulgaria, Netherlands, Estonia, LV fluctuate around 50% and in Cyprus, Germany, Luxembourg, Austria, Belgium, Hungary, Finland, Denmark, Sweden, Ireland, Malta, and France, they account for a proportion below 50%. Similarly, the relative weight of social benefits has decreased compared to Q1 households.

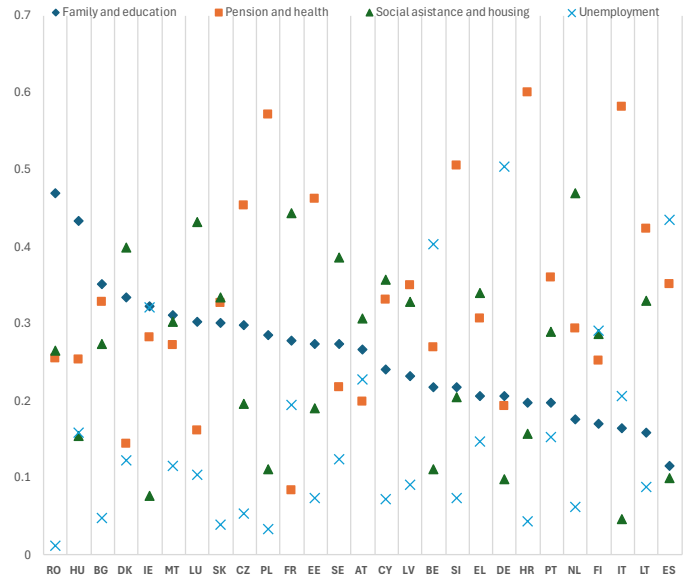
The central left and right panels show a very similar situation to the previous one. In most countries, pensions and health benefits represent a larger proportion of the total benefits received by households belonging to Q3 and Q4, again with a high degree of heterogeneity between territories. For the sake of illustration, for households belonging to Q3 in Poland, Croatia, and Italy, they account for a proportion close to 80%, while in France, for example, it does not reach 20%. These maximum values decrease for households belonging to Q4 but the countries remain in their position. Likewise, in Sweden, Estonia, Hungary, and Malta, family benefits continue to

represent a greater proportion of the total benefits received. Additionally, in both panels, it can be observed that social benefits continue to lose relative weight, as expected. Finally, notable cases include Finland, Portugal, Spain, and Italy, where unemployment benefits are the second most important in relative terms (the first in France).

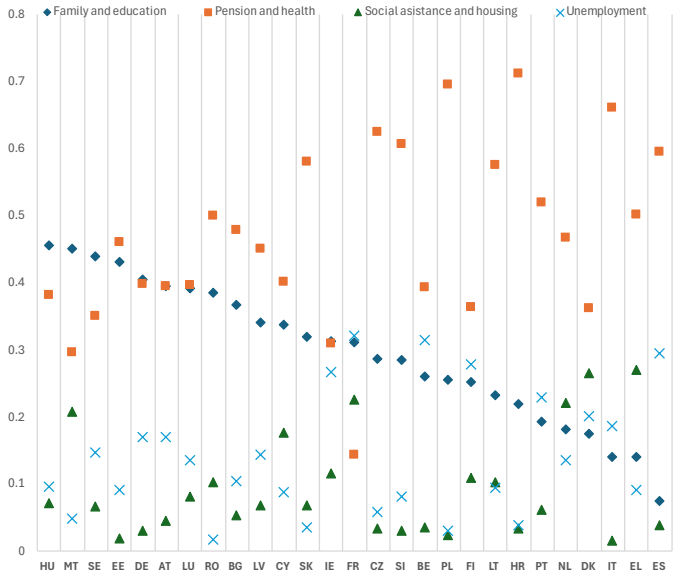
Lastly, in the bottom panel, corresponding to benefits received by the richest households, this trend becomes further established. Disability, old age, and widowhood benefits are the ones with the greatest relative weight, except for Estonia, Romania, Hungary, and Malta. However, the case of unemployment benefits in Belgium, France, Cyprus, and Italy is surprising as they gain importance compared to all previous situations. Finally, it is worth noting the case of Spain where family and social assistance benefits barely have any weight in any of the panels.

Figure 3.2 Mix composition of benefits by quintile.

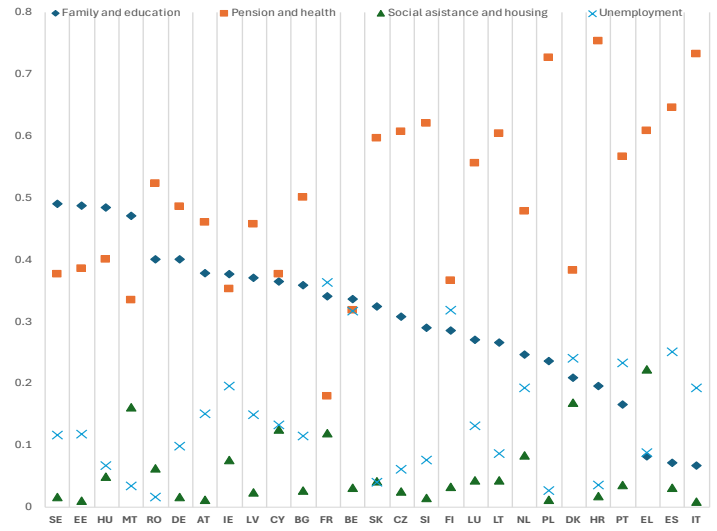
Q1



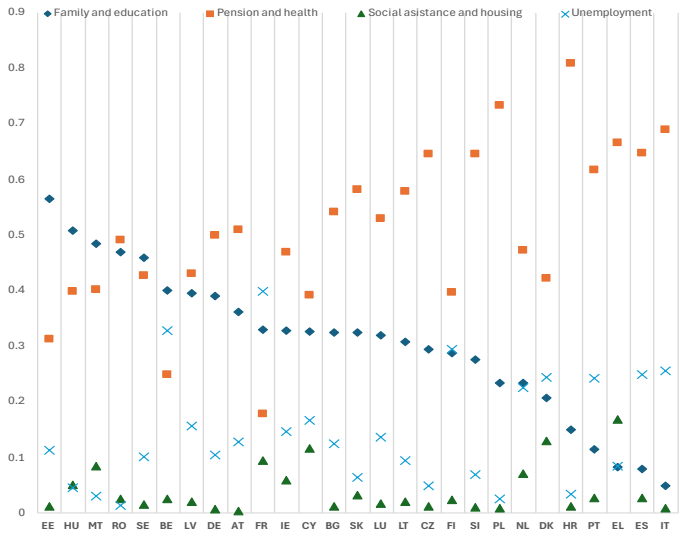
Q2



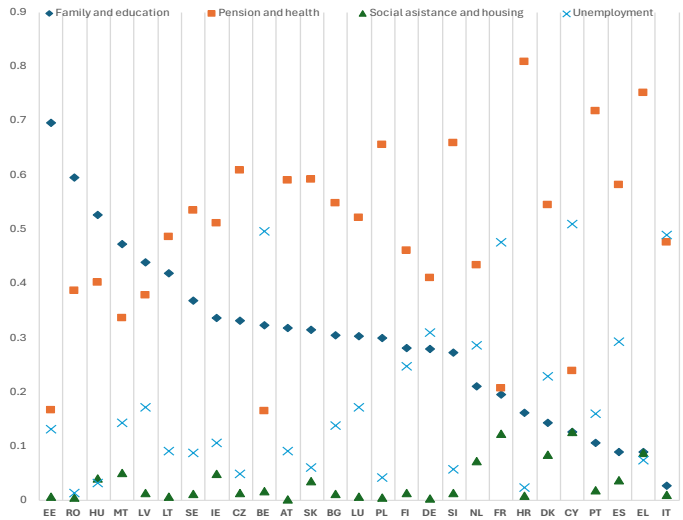
Q3



Q4



Q5



Source: own elaboration based on EUROMOD output. Country average data for period 2008-2019. Countries have been ordered according to Family and education benefits to facilitate visualization.

So far, in the two previous figures, we have analysed the quantity and composition of benefits directed towards each quintile of the population. However, it is necessary to also include the effects of these benefits to fully capture all differences between welfare states. That is, how much they represent over household's income and how much they redistribute. For this purpose, Figures 3.3 and 3.4 show the degree of redistribution, progressivity, and level of the previously analysed benefits in addition to taxes and social insurance contributions (SICs). In this manner, we manage to capture possible differences and similarities in a more precise manner.

In the top left panel, we can observe the following regarding family and education benefits. While most European countries are relatively clustered, Ireland stands out from the group, achieving higher levels of redistribution both in terms of progressivity and the level of the benefit. Additionally, within the group, we also observe that not only Denmark; Sweden, Luxembourg, but also Hungary are the next countries that achieve the highest redistribution by combining progressivity with the level of the benefit. At the same time, Spain, Greece, Italy, and Portugal achieve the least degree of redistribution with this type of benefits despite being progressive. It is the low weight what ends up undermining the effects of progressivity. The rest of the countries are in an intermediate situation.

In the top right panel, which refers to pension and health benefits, there is slightly more dispersion observed compared to the previous situation. Italy and Hungary stand out in terms of the redistribution achieved through these benefits, both in progressivity and level. Denmark, Luxembourg, Spain, and Slovenia are relatively close, achieving similar levels of redistribution, although in the case of Denmark and Luxembourg, it is achieved through greater progressivity. On the other hand, the countries that achieve the least redistribution are Latvia and Bulgaria, but also Malta and France. In the case of the former, this is due to their benefits being the least progressive in the sample. As for the latter, despite reaching a moderate level of progressivity, the low weight stands out.

If we now focus on the bottom left panel, which refers to social assistance and housing benefits, the following observations can be made. Denmark, Netherlands, and Luxembourg are the countries with the most redistributive benefits, especially highlighting the role of the benefit level, although in Netherlands and Luxembourg progressivity also stands out. The next group includes Sweden, Finland, and France, where the benefit levels -also in terms of the progressivity- are similar to the case of Finland and Sweden. Likewise, Poland, Lithuania, Latvia, Estonia, Bulgaria, Croatia, and Czech Republic show strong similarities in terms of the progressivity of their benefits, so the slight differences in the level of redistribution achieved are explained by variations in the level. Finally, what was observed in the two previous figures about the limited redistribution

in the cases of Italy and Spain is confirmed, due to the combination of low progressivity and low level.

Finally, in the bottom right panel, referring to unemployment benefits, it is where more significant differences are observed. Hungary, Spain, and Austria are the countries where the highest redistribution is achieved through this type of benefit, generally due to its level but also its progressivity. Similarly, Lithuania, Poland, Romania, Croatia, and Latvia seem to be relatively close, with their redistributive differences mainly explained by the weight of the benefit. On the other hand, Denmark, Sweden, Luxembourg, Netherlands, and Belgium, as well as Italy and Slovenia, form a group where they stand out for achieving little redistribution, explained by low progressivity and a low level of the benefit.

The left panel of Figure 3.4 focuses on taxes. In this regard, different groups of states also seem to emerge. On one hand, Germany, Austria, Luxembourg, Netherlands, and Ireland exhibit similarities in terms of the level of redistribution achieved through taxes, but also in terms of progressivity and level. Likewise, we find another relatively close group consisting of Spain, Greece, and Slovenia, for which the slightly lower level of redistribution compared to the previous group is explained by the level, since the levels of progressivity are similar. Latvia, Lithuania, Estonia, Hungary, and Romania also seem to be grouped together, although France is also included. This grouping is mainly determined by the progressivity of their tax systems. Finland and Sweden almost overlap, reflecting a high degree of similarity. Lastly, it is worth noting the case of Denmark, which is very close to the origin point, both in progressivity and redistribution.

Regarding the left panel, which refers to social insurance contributions (SIC), European countries are grouped forming a diagonal. In this sense, two groups can be distinguished, depending on which part of the graph they are located in. Those situated in the lower left region are states where SICs are regressive, thus not serving as an equalizing element. Within this group are countries such as Spain, Luxembourg, Denmark, Malta, Germany, Austria, Greece, Sweden, Cyprus, Poland, France, and notably, Netherlands. The other group, in turn, consists of countries whose SICs do play a redistributive role, making them progressive. This group includes Portugal, Lithuania, Estonia, Slovakia, Bulgaria, Latvia, Croatia, Hungary, Czech Republic, Belgium, Finland, Italy, and Ireland.

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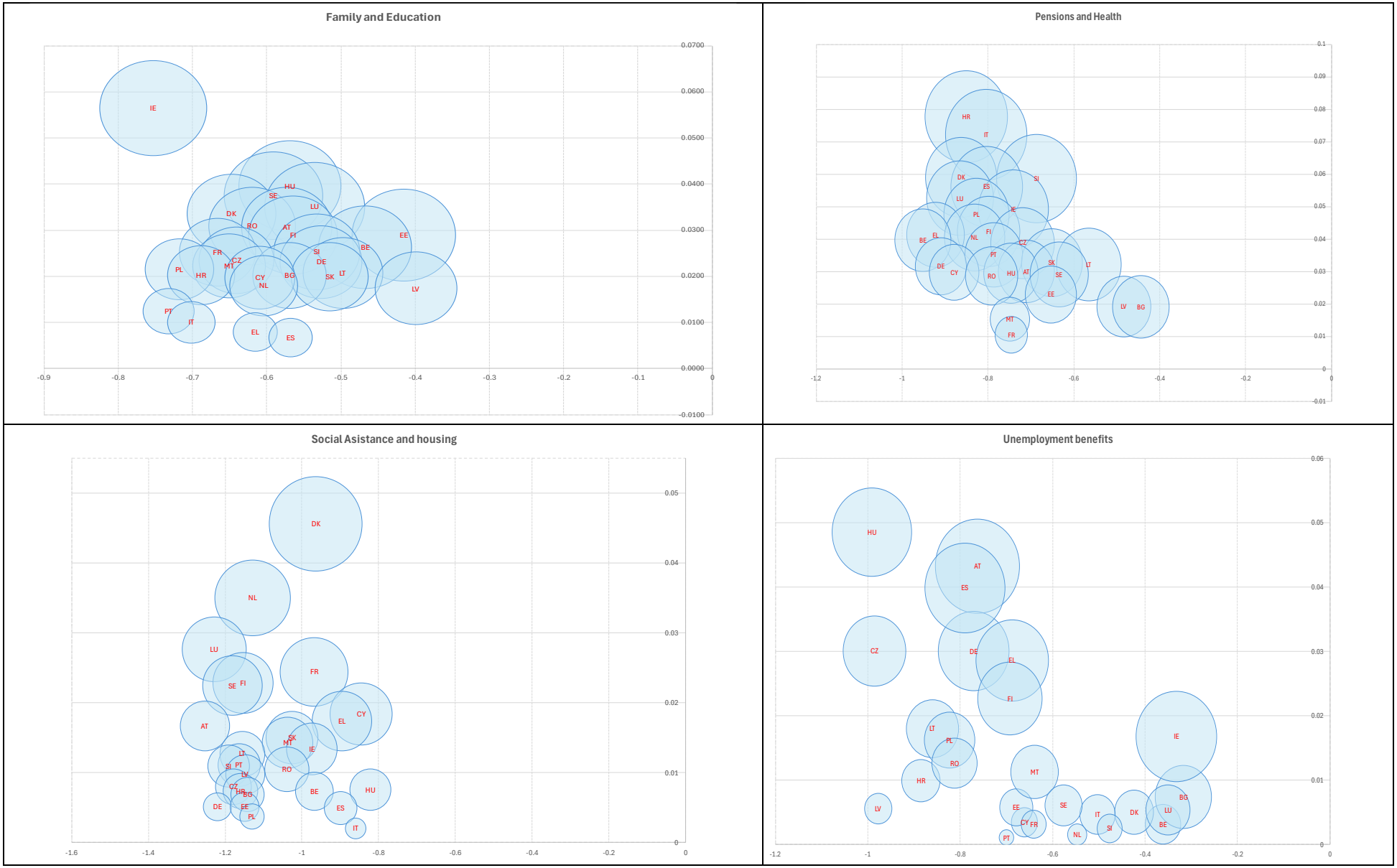
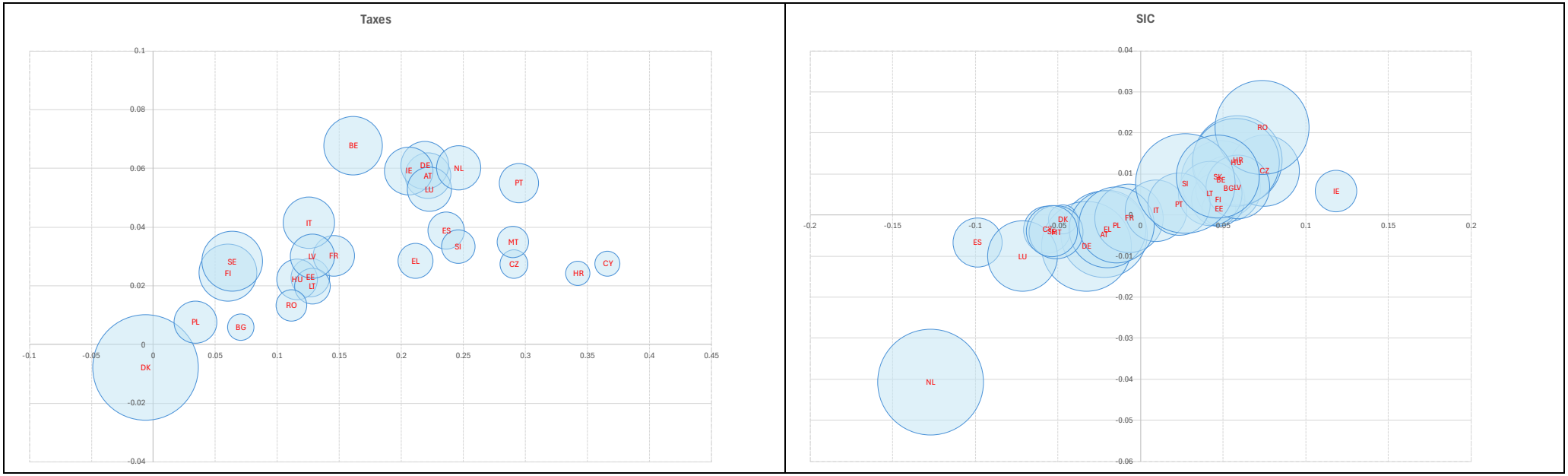
Figure 3.3 Redistribution, progressivity and level of benefits.



Source: own elaboration based on EUROMOD output. Average data for period 2008-2019. X axis represent progressivity measured by Kakwani index. Y axis represent redistribution. Size of the bubble represent the level.

Figure 3.4 . Redistribution, progressivity and level of taxes and SICs.



Source: own elaboration based on EUROMOD output. Average data for period 2008-2019. X axis represent progressivity measured by Kakwani index. Y axis represent redistribution. Size of the bubble represent the level.

3.2 Methodology

As mentioned before, we are interested in finding if the different European countries group into the usual welfare taxonomies or if, on the contrary, new aggrupation emerges. To do so, we rely on cluster techniques which are commonly used in the welfare literature to analyse internal dependencies in large datasets. The fundamental objective of this type of unsupervised algorithm is to link units of the sample forming exhaustive groups in such a way that minimizes intragroup variance while maximizing intergroup variance.

Before conducting the cluster analysis, the first step in our methodological approach is to reduce the dimensionality of our database and extract the fundamental information found on the data by applying Principal Component Analysis. In this regard, we establish the criterion that the components must explain at least 80% of the variance of the data. Once we have addressed the dimensionality of our database, we rely on unsupervised cluster techniques to explore potential common patterns. More precisely, we employ Hierarchical Clustering techniques (HCA), as they offer the advantage of not having to pre-specify the number of clusters to be obtained. Within these techniques, we have opted for an agglomerative algorithm, whereby we start from a situation in which each country forms an individual cluster, and iteratively, pairs of groups are merged until a single cluster containing the entire sample is achieved. At each step the pair of clusters with minimum between-cluster distance are merged.

Following Kammer et al. (2012) and others we have chosen squared Euclidean distance as a (dis)similarity measure,. As a linkage method, we have chosen Ward's minimum variance method. This method is based on minimising the increase of the within-cluster error sum-of-square in each stage (Everitt, 2011).

$$E_m = \sum_{l=1}^{n_m} \sum_{k=1}^{p_k} \left(x_{ml,k} - \overline{x}_{m,k}\right)^2 \qquad (1)$$

Finally, to counterbalance the influence of outlier values, all data has been previously standardized.

Hierarchical Clustering Algorithms do not yield a predetermined number of groups; rather, the result is a single cluster that includes all countries in the sample. Usually, the final output of the analysis is a tree graph (called *dendrogram*) in which the entire path of union of the sample is represented. Therefore, we must establish a criterion to specify when the algorithm should stop.

In our analysis, we have set the similarity degree as the stopping criterion. More precisely, we have specified the threshold of 25 of similarity cut point[38].

As we discussed in the introduction, the most standard cluster analysis techniques do not allow for addressing the temporal dimension. To overcome this issue, we have estimated each year independently what enable us to study the stability of the groups over the period. Additionally, to achieve a medium-term perspective beyond annual volatility of indicators, we repeated the analysis for the following scenarios: 3-year moving average, 5-year moving average, mean of the recessionary period of the cycle (2008-2013), and mean of the expansionary period (2014-2019). This, together with the analysis of individual years, yields a total of 32 possible scenarios. Thus, for each scenario, we analyse whether two countries are grouped in the same cluster, setting the maximum dissimilarity degree at a height of 25.[39] The final result of our analysis will provide the total number of times, out of the 32 iterations, that two countries are grouped together.

4. Results

Table 3.1 shows the result of the cluster analysis for all countries across the 32 iterations mentioned. In this way, it visually shows which countries have a higher degree of similarity and therefore which ones tend to cluster together. At first glance, the following points can be highlighted: Denmark is the country in the sample with the least similarity to any other country. It hardly ever coincides with any other country, and the cases where it does coincide with others are with a very low proportion of scenarios. The countries with which it shows the highest percentage of coincidence are Finland and Sweden, although it only coincides with them 2 times over the 32. Furthermore, Belgium is another country that doesn't show much similarity with the rest of European countries, except for Germany, with which it coincides 20 times.

Austria, Luxembourg, and Netherlands exhibit a significant degree of similarity. For instance, Luxembourg and Austria consistently cluster together in all iterations, and they coincide with Netherlands in 19 instances. However, they also show a very high degree of similarity with Slovenia and Slovakia. Another group that exhibits a high degree of association consists of Bulgaria, Lithuania, Latvia, and Estonia, which coincide together in virtually all iterations. The lowest degree of coincidence they reach is 28 out of 32 times. Finland and Sweden also exhibit an enormous degree of association, coinciding together in 27 instances. The next countries with which they show a higher degree of similarity are Belgium and Germany, but also Estonia.

[38] In Table A3.3 in the appendix we have repeat the analysis but to 15, 20 and 35 thresholds as a robustness check.

[39] This value matches with previous related literature. For the sake of robustness, we have run other scenarios with alternative values. Results keep the main conclusions and those different evolve as expected. For instance, consider higher values for height means that the likelihood of being grouped together is also higher. See Table A.3 for details.

Greece tends to associate primarily with Portugal and Poland (22 out of 32 iterations), but it also shows a moderate degree of association with Czech Republic, Romania, Hungary, and Malta, which may not be in line with what one would expect from previous literature. Spain, however, does show a stronger association with what would be expected from previous literature to be its reference group. Thus, it mainly coincides with Italy, Portugal, but not with Greece. Italy shows strong similarities with Spain, Poland and Portugal which, in turns, shows stronger similarities with Spain, Greece and Poland.

Hungary, on the other hand, shows its highest degree of coincidence with Romania and a minor propensity to coincide with Czech Republic, but also tends to align, at lower proportion- with Slovenia, Slovakia, Poland, Greece and Ireland. All of this seems to indicate that both group of Mediterranean and Eastern European countries has tended to homogenize over the period.

Finally, France seems to have a strong propensity to coincide with Malta and Cyprus and to a much lesser extent with Netherland, Finland. Also, with the Eastern-European countries (Bulgaria, Latvia, Estonia) and Greece. Pretty similar conclusions may be extracted for the case for Cyprus. It aligns with France and Malta primarily and in lower proportion with the Eastern-European. Malta also tends to cluster with France and Cyprus and to lesser extent with Greece, Portugal, Hungary and Romania. This seems to indicate that Cyprus, Malta and France could be forming a different cluster on their own.

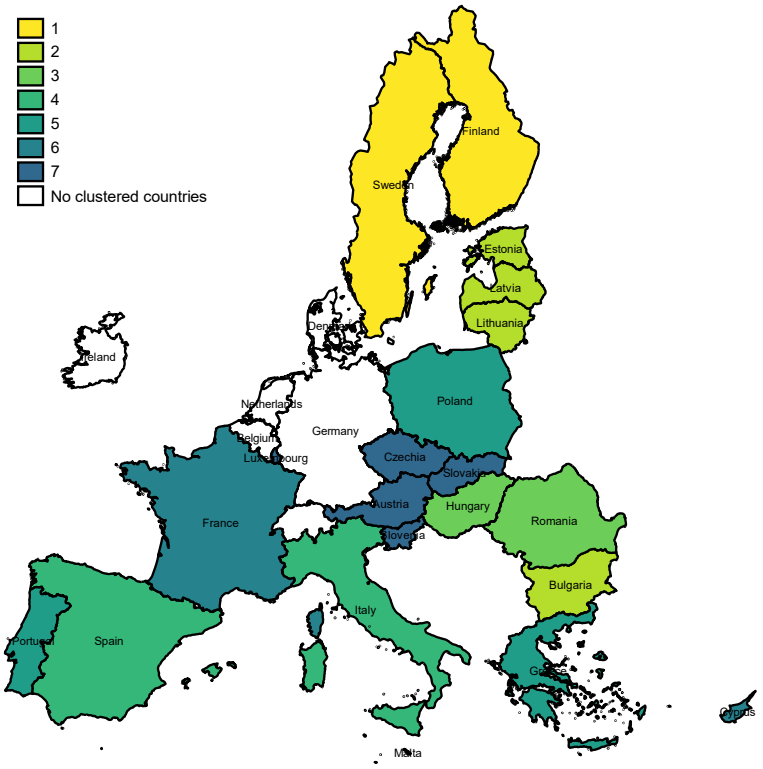
Table 3.1 Results derived from the hierarchical cluster analysis. All scenarios included.

	AT	BE	BG	CY	CZ	DE	DK	EE	EL	ES	FI	FR	HU	IE	IT	LT	LU	LV	MT	NL	PL	PT	RO	SE	SI	SK
AT	32	2	4	3	18	7	0	2	3	1	11	1	10	15	0	6	32	3	3	19	4	6	9	16	25	23
BE	2	32	3	1	1	20	0	6	4	11	14	9	5	5	12	1	2	3	1	2	5	7	5	9	1	1
BG	4	3	32	11	5	6	0	28	1	7	11	10	6	3	8	28	4	31	9	2	3	3	5	12	4	4
CY	3	1	11	32	5	3	1	11	10	2	4	23	5	4	1	11	3	11	26	10	2	7	5	5	2	3
CZ	18	1	5	5	32	11	0	3	13	6	3	1	18	13	6	5	18	4	6	12	15	16	17	4	22	24
DE	7	20	6	3	11	32	0	9	10	14	14	6	6	12	13	4	7	6	6	5	10	17	5	14	5	5
DK	0	0	0	1	0	0	32	0	1	0	2	1	0	0	0	0	0	0	0	0	0	0	0	2	0	0
EE	2	6	28	11	3	9	0	32	1	8	14	10	4	2	9	26	2	29	9	1	2	3	3	15	2	2
EL	3	4	1	10	13	10	1	1	32	11	1	10	15	5	9	1	3	1	13	11	22	22	14	2	8	9
ES	1	11	7	2	6	14	0	8	11	32	4	3	1	4	29	6	1	7	4	2	14	19	1	3	1	2
FI	11	14	11	4	3	14	2	14	1	4	32	10	6	11	3	9	11	11	6	5	0	4	6	27	5	5
FR	1	9	10	23	1	6	1	10	10	3	10	32	4	4	1	9	1	10	22	10	0	6	4	7	0	0
HU	10	5	6	5	18	6	0	4	15	1	6	4	32	14	0	5	10	5	10	6	16	10	31	6	15	16
IE	15	5	3	4	13	12	0	2	5	4	11	4	14	32	2	2	15	2	9	2	4	9	13	11	9	10
IT	0	12	8	1	6	13	0	9	9	29	3	1	0	2	32	7	0	8	1	1	16	16	0	2	2	3
LT	6	1	28	11	5	4	0	26	1	6	9	9	5	2	7	32	6	29	8	5	2	2	4	11	6	5
LU	32	2	4	3	18	7	0	2	3	1	11	1	10	15	0	6	32	3	3	19	4	6	9	16	25	23
LV	3	3	31	11	4	6	0	29	1	7	11	10	5	2	8	29	3	32	9	2	2	3	4	12	3	3
MT	3	1	9	26	6	6	0	9	13	4	6	22	10	9	1	8	3	9	32	9	4	10	10	7	1	2
NL	19	2	2	10	12	5	0	1	11	2	5	10	6	2	1	5	19	2	9	32	6	9	6	8	21	19
PL	4	5	3	2	15	10	0	2	22	14	0	0	16	4	16	2	4	2	4	6	32	18	15	1	11	12
PT	6	7	3	7	16	17	0	3	22	19	4	6	10	9	16	2	6	3	10	9	18	32	9	5	9	10
RO	9	5	5	5	17	5	0	3	14	1	6	4	31	13	0	4	9	4	10	6	15	9	32	5	14	15
SE	16	9	12	5	4	14	2	15	2	3	27	7	6	11	2	11	16	12	7	8	1	5	5	32	9	8
SI	25	1	4	2	22	5	0	2	8	1	5	0	15	9	2	6	25	3	1	21	11	9	14	9	32	30
SK	23	1	4	3	24	5	0	2	9	2	5	0	16	10	3	5	23	3	2	19	12	10	15	8	30	32

Source: Own elaboration.

As proved, this approach allows us to observe with very detail the similarities between countries. However, it is necessary to set a limit to define the formation of different groups. In this case, we decided to establish a coincidence rate of over 65% of the times to affirm that two countries belong to the same welfare state. Thus, Figure 3.5 shows the existing groups once we apply this criterion[40].

Figure 3.5 Groups of welfare states.



Source: Own elaboration derived from the cluster analysis

From Figure 3.5 we conclude that there is a group of countries that do not exceed the threshold of coincidence with any other, and therefore, we cannot claim that they belong to any supranational welfare state model or regime. These countries are Ireland, Netherlands, Belgium, Denmark and Germany and are represented in white colour. Some of these results are congruent with previous literature. Among others, Vrooman (2012) has analysed Netherlands as a hybrid case between Social-Democratic and Corporatist. In Kammer et al (2012) Belgium as well as Netherlands appears as a different group, although as the author apply HCA, the countries end up joying the Nordic's group. In addition, in their analysis Ireland only cluster with United Kingdom, thus, by not having included it in our analysis, it is reasonable for Ireland to appear as an independent country. In the case of Denmark, usually align with Sweeden and Finland, in Korpi

[40] Table A3.4 in the appendix show the proportion of coincidence of each country with any other country in the sample.

(2000) the author differentiates between those countries and Denmark according to a series of institutional characteristics of the welfare systems. Finally, the most surprising result corresponds to the case of Germany, which tends to be commonly associated with the Central European countries of the Corporatist model, yet in our case, it appears isolated.

On the other hand, regarding the countries that do exceed the threshold of coincidence, we can observe that seven distinct clusters emerge. A first cluster consist of Sweden and Finland, which as we previously observed, show a very high probability of coincidence. This similarity is very well known in the literature. Among others, Bambra (2005), Korpi (2000), Halaskova (2018) as well as the original work of Esping-Andersen (1990) presented both countries together when analysing different characteristics of the welfare states. A second cluster is formed by Estonia, Latvia, Lithuania and Bulgaria, which also tends to be grouped together in the related literature, especially Baltic countries. However, surprisingly, Hungary and Romania do not belong to this group; instead, they form a separate cluster. Thus, our results do not suggest the existence of a single welfare model for Eastern European post-communist countries but rather two distinct ones: one comprising the former Baltic Republics plus Bulgaria, and another consisting of Hungary and Romania. The lack of convergence regarding welfare states features on post-communist countries also has been found on Piotrowska and Rae (2018), and Castle and Obinger (2008).

The fourth cluster corresponds to Italy and Spain, that also presented a very high degree of coincidence. However, despite also exhibiting a high percentage of similarity with Greece and Portugal, these countries form an independent group in our analysis (the fifth one), along with Poland. Therefore, it appears that it is no longer possible to speak of a group of Mediterranean countries, as suggested in Ferrera (1996), but of two fragmented groups, with Poland joining one of them. Although these results may appear somewhat surprising, Piotrowska and Rae (2018) also found that. For the sake of concreteness, for the year 2004, Poland tended to align with Mediterranean countries rather than those of Central Europe. Thus, our results seem to confirm this trend.

The sixth cluster is formed by Malta, Cyprus but also France. Finally, the seventh cluster is formed by Luxemburg, Austria, Czech Republic, Slovenia and Slovakia. From this cluster, the countries that usually group together are Luxembourg and Austria (Kammer et al., 2012). However, some of the other countries were also found together in other works. For instance, Slovenia aligns with the Netherlands in Piotrowska and Rae (2018), where it is more closely associated with the Corporatist model than with any welfare model in Central or Eastern Europe. Furthermore, Lauzadyte-Tutliene et al. (2018) find that both the Czech Republic and Slovakia, along with Slovenia, belong to a broader group representing Central European countries with post-communist heritage.

However, two of our clusters do not exhibit mutual membership. That is, depending on the pairs of countries analysed, the percentage of coincidence either exceeds or falls below the threshold. This is observed for cluster 7, composed of Austria, Luxembourg, Slovakia, Slovenia, and the Czech Republic. Although all countries coincide in the same group, it is also possible to identify two smaller groups: on one hand, one containing Slovakia, Slovenia, and the Czech Republic, and on the other hand, another containing Austria, Luxembourg, Slovakia, and Slovenia. The same phenomenon is observed with the cluster consisting of Portugal, Greece, and Poland. Although it is possible to find them together in more than 65% of the scenarios, it is also possible to identify a group composed solely of Portugal and Greece, as well as another group consisting of Poland and Greece (see Figure 3.6). This could be explained by the introduction of the temporal dimension in our analysis, where we may be capturing incipient or not fully established trends.

Figure 3.6 Groups not mutually exclusive (65%)

Source: Own elaboration

5. Concluding remarks

In this paper we carry out an empirical exploration of European Union welfare states classification for the period 2008-2019. We apply Cluster analysis techniques. Specifically, we employ hierarchical cluster analysis (HCA) with a maximum dissimilarity of 25 points. To do so, we adopt a novel approach both in the selection of the indicators and in the empirical approach adopted. Regarding the former, we rely on EUROMOD output microdata to compute a broad selection of indicators about how the welfare states distribute their benefits and taxes among the population as well as how they conform their composition on an aggregated level. For the latter, we introduce the temporal perspective, which is typically absent in this type of analysis due to the static nature of most clustering techniques. To address this, we conduct the analysis independently for each year of the period as well as for a series of transformations thereof (moving averages and distinction of the cycle phase) with the aim of avoiding the bias introduced by specific years into the resulting classification.

In a first exploratory analysis we observed that there are notable differences between European countries. For example, Latvia, Estonia, Lithuania and Bulgaria are the countries that, on average, assign a smaller proportion of their benefits to poorest households. On the contrary, Greece, Netherlands, Poland and Germany are the more generous countries with the poorest. However, the differences are not only limited to the number of benefits targeted at each income group but also in the type of benefit itself. Thus, while the Baltic countries devote a greater part of their efforts to family benefits and much less to social assistance, the latter carries more weight in countries such as the Netherlands and Greece. This is why it is necessary to include simultaneously in the analysis indicators of diverse nature that capture different dimension of welfare states.

Our results point to the existence of 7 different EU clusters, most of them congruent with the usual classifications, as is the case of the Nordic countries or Eastern Europe. However, from a closer look, it can be inferred that although many of the findings from theoretical contributions and empirical studies from the 1990s and early 2000s are still valid, some diverging trends have solidified, altering these groupings. For instance, the well-known Mediterranean model appears to have fragmented into two. On the contrary, some of the groups appear to have merged into a mixture of both. This is the case of Austria and Luxembourg, which have joined Slovakia, Slovenia, and the Czech Republic. In addition, we find a few of countries that do not cluster with any other but rather oscillate between groups, as is the case of Belgium or Netherlands. This goes in line with the statements of Arts and Gelissen (2002), which claimed that ‘in real world’ most of the countries would lie between ideal models, being hybrid cases.

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Appendix 3

Table A3.1 Literature review

Paper	Variables included	Cluster method	Welfare taxonomies
Arcanjo (2011)	The first classification is based on social effort and contribution dominance, while the second is based on transfer effort and service effort. The four indicators are calculated for 1990 and 2006, for ten European countries, as representative of different regimes: the United Kingdom (UK) and Ireland (liberal), Denmark and Sweden (social-democratic), France and Germany (conservative), Portugal, Spain, Italy and Greece (southern).	No clustering techniques: Descriptive analysis	The results obtained do not permit to establish closed clusters. However, these results do not seem to confirm some previous groupings, with countries previously grouped together in the literature behaving atypically.
Bambra (2005)	**Cash benefit index formed by: Pensions:** (1) Minimum pension benefits for a standard production worker earning average wages (2) Standard pension benefits for a normal worker (3) Contribution period required for a minimum pension (4) Individual's share of pension financing (5) Percentage of the (relevant) population covered by the program; **Unemployment:** (1) Pre-taxation benefit replacement rates for a standard worker during the first 26 weeks of unemployment (2) Number of weeks employment prior to qualification for benefit (3) Number of waiting days before benefits are paid (4) Usual number of weeks in which benefit can be maintained (5) Percentage of the (relevant) population covered by the program; **Sickness:** (1) Pre-taxation benefit replacement rates for a standard worker during the first 26 weeks of sickness (2) Number of weeks employment prior to qualification for benefit (3) Number of waiting days before benefits are paid (4) Number of weeks in which benefit can be maintained (5) Percentage of the (relevant) population covered by the program. **Health care index formed by: Health care** (1) Private health expenditure as a percentage of GDP – this factor refers to the extent of private financing by identifying the extent of a country's total income that is spent on private health care (2) Private hospital beds as a percentage of total bed stock – this factor is used to express the extent of private provision at a practical level within a health care system (3) The percentage of the population covered by the health care system – this shows the extent of general access provided by the public health care system	No clustering techniques. Based on Esping-Andersen (1990) decommodification index. The individual country score for each index has been translated into a percentage of the total decommodification score produced by that index. Numerical description of the relationship of an individual country's score to the mean (and standard deviation) for four (one–four) of the five factors that make up each index	The resulting analysis suggests that when services are added into the comparative analysis of welfare state regimes there are five welfare state clusters: Social Democratic, Liberal, Conservative, and subgroups within both the Liberal and Conservative regimes.

Chybalski and Marcinkiewicz (2021)	**Size of a welfare state (GS):** social security contributions (GS1), total social protection expenditure (GS2), tax wedge (GS3), and tax revenue (GS4).; **public–private mix (PP):** the public–private mix of social expenditure (PP1), health expenditure within government schemes and compulsory contributory health care financing schemes (PP2), health expenditure within voluntary healthcare payment schemes (PP3), household out-of-pocket payments for healthcare (PP4), the public–private mix of spending on education (PP5), coverage of private pension plans (PP6), and total assets in funded and private pension arrangements (PP7); **pro-family component (FA):** length of maternity leave (FA1), length of parental leave (FA2), total duration of paid leave (FA3), length of paid father-specific leave (FA4), maternity leave payment rate (FA5), children aged 0–2-years-old participating in formal early childhood education and care (ECEC) services (FA6), children aged 3–5-years-old enrolled in pre-primary education or primary school (FA7), participation rates in centre-based out-of-school-hours care services (FA8), and the average size of households (FA9); **pro-female component (FE):** includes the gender pay gap (FE1), the employment rate gap (FE2), the share of women inventors (FE3), maternal employment rates (FE4), and the difference in net transfers to government (tax paid minus benefits received) between single-earner and equal dual-earner couple households earning 133% (FE5) and 200% (FE6) of the average wage	1) Hierarchical agglomerative clustering to set the initial number of clusters. 2) K-means clustering to determine the final clusters composition providing their number indicated in the first step. 3) analysis of variance to test the discrimination properties of each dimension of a welfare state (reflected in synthetic indicators) in grouping countries.	4 groups: **(1) Liberal:** Iceland, Ireland, Latvia, Switzerland and UK. **(2) Medium-public pro-female:** Denmark, Finland, Greece, Luxembourg, Netherlands, Norway, Portugal, Slovenia and Sweden. **(3) Medium-public:** Czech Republic, Estonia, Hungary, Poland, Slovakia and Spain. **(4) Extensive public:** Austria, Belgium, France, Germany and Italy.
Danforth (2014)	Net annual replacement rate for each type of insurance benefit for a single production worker, average wages; Number of years of contribution required to qualify for each benefit, made in the relevant reference period; Net minimum annual replacement rate for an old-age pension for a single production worker; Proportion of insurance fund receipts derived from contributions made by an insured worker; Number of legislated waiting days at the beginning of a spell, during which no benefit is paid; Number of weeks for which the benefit is paid to a single production worker with a full work record; Civilian government employment as a percentage of the working-age population (i.e. aged 15–64 years); Share of the population above the normal pension age that is receiving a pension; Percentage of the population aged 15–64	Agglomerative hierarchical cluster analysis and model-based cluster analysis.	Depending on the year and the set of measured include. See Table 4 to 7 in Danforth (2014) for more detail.

	that will be eligible for pensions at the normal age of retirement; Percentage of the labour force that is covered by each type of insurance; Public share of total spending on health care as a percentage of GDP; Number of major, occupationally distinct schemes in the public pension system; Net annual replacement rate for a single production worker, average wages, for each type of insurance benefit as a percentage of the net maximum replacement rate; Estimated Gini index of net disposable household income; Difference between gross and net Gini indexes as a percentage of gross Gini index; Percentage of households with disposable incomes below 50 percent of the median household income; Percentage of children in households with disposable incomes below 50 percent of the median household income; Percentage of elderly households with disposable incomes below 50 percent of the median household income; Percentage of women aged 15–64 years who are in the labour force; Generosity of parental level benefit in terms of full weeks of pay for a typical production worker.		
Farkas (2019)	2 different analyses: (1) Based on the six Worldwide Governance Indicators (WGI). Two of the six composite indicators (**voice and accountability, and political stability and absence of violence/terrorism**) capture perceptions of the quality of democratic institutions. The other four indicators relate to government effectiveness, professionalism (**government effectiveness, regulatory quality**) and rule of law, impartiality (**rule of law, control of corruptio**n) more closely. (2) Based on the World Economic Forum (WEF) indicators - in order to conduct a control cluster analysis-diversion of public funds, public trust in politicians, irregular payments and bribes, favouritism in decisions of government officials, transparency of government policymaking, burden of government regulation, efficiency of government spending, efficiency of legal framework in settling disputes and efficiency of legal framework in challenging regulations.	Hierarchical clustering with Ward's variance method	It can be found a strong division between the northern and western countries on the one hand and the eastern and southern countries on the other. "Estonia is the only eastern European country which belongs to the countries with good quality of governance. The cluster of countries with the best quality of governance comprises all of the northern and western European member states with the exception of France and Belgium. The southern and eastern European countries belong to one of two clusters. The eastern and southern countries' cluster with medium quality of governance includes Cyprus, Czech Republic, Latvia, Lithuania, Malta, Poland, Portugal, Slovakia, Slovenia and Spain. The eastern and southern countries' cluster with medium quality of governance includes Cyprus, Czech Republic, Latvia, Lithuania, Malta, Poland, Portugal, Slovakia, Slovenia and Spain."

Ferragina, Seeleib-Kaiser and Spreckelsen (2015)	Child poverty, Youth poverty, Female Employment, In-education, Male worker poverty, Old age poverty, Unemployment poverty, Replacement rate, Inequality reduction (Difference Gini)	Complete linkage with Euclidean distance as the dissimilarity measure and then iterative methods	**(A) Welfare states outcome: (1) Conservative:** Belgium, Ireland, France, Austria. **(2) Social democratic:** Denmark, Sweden, Finland, Netherlands. **(3) Liberal:** Germany and United Kingdom. **(4) Mediterranean countries:** Greece, Spain, Italy, Portugal. **(B) Outcome clusters for old social risks: (1)** Belgium, Denmark, Sweden, Austria and Finland. **(2):** France and Netherlands. **(3):** Germany. **(4):** Ireland, Greece, Spain, Portugal, Italy and United Kingdom. **(C) Outcome clusters for new social risks: (1)** Belgium, Ireland and France. **(2):** Greece, Spain, Portugal and Italy **(3)** Denmark, Sweden, Germany, Netherlands and Finland. **(4):** Austria and United Kingdom.
Gough and Abu Sharkh (2011)	**Government welfare spending** (public spending on education and health as a share of gross domestic product [GDP] and social security contributions as a share of total government revenues); P**ublic service delivery** (immunisation against measles and secondary school enrolment of females); **the scale of external transfers** (official aid and remittances from overseas migrants); and **welfare outcomes** (life expectancy at birth and the illiteracy rate of young people aged 15–24 years).	They begin with dendrograms generated by hierarchical cluster analysis and observe the number of major clusters these identify. At the next stage, we turn to K-means cluster analysis (KCA), using the previous analysis to specify numbers of clusters in advance.	The data sets exclude the OECD world
Halaskova (2018)	Indicators of the structure of general government expenditure on social protection at the COFOG II level: **a)** sickness and disability, **b)** old age and survivors, **c)** family and children, **d)** unemployment, housing and social exclusion.	Hierarchic clustering: the furthest neighbour method (the determining factor is the maximum distance between objects). Distances of objects are measured by squared Euclidean distance	4 CLUSTER: **First** cluster: BE, DE, ES, HR, LU, HU, PL, SI, FI, SE, UK; **Second** cluster: BG, CZ, EE, CY, LV, LT, MT, RO, SK; The **third** cluster: DK, IE, NL; **Fourth** cluster: EL, FR, IT, AT, PT
Hasanaj (2022)	Concentration on old risk, Configuration, Instruments, Market and Measures. See Table 3 in Hasanaj (2022) for a more detailed of the indicators included.	Model-based clustering	Reactive and Proactive Welfare States. See Hasanaj (2022) for more details.

Hook (2015)	The percentage of two-parent families that are (1) dual full-time or female sole or main employee, (2) male full-time and female part-time (one-and-a-half earner), (3) male sole earner and (4) neither employed. Additionally: mothers' level of educational attainment.	Hierarchical cluster analysis (method: Ward's linkage)	3 cluster: **(1)** Denmark, Sweden, Norway and Finland. **(2)** UK, Ireland, Austria, Luxembourg, Japan, Germany and Switzerland. **(3)** USA, France, Spain, Greece and Italy.
Hudson and Küner (2010)	Education investment, active labour market policy (ALMP), income protection and employment protection	Fuzzy-set ideal type analysis	16 typologies: 4 pure (combine both productive and protective elements successfully and constitute the productive−protective) and the rest hybrids. See Hudson and Küner (2010) for more detail.
Kim and Lee (2008)	(1) Based on universality and income replacement rate: universality; income replacement rate; active labour market policy (ALMP); employment security. (2) Based on combinations of causal variables: per capita GDP; aged dependency ratio; pension maturity rate; union density; constitutional structure index and degree of decommodification.	K-means cluster analysis	**Welfare to work type** (high welfare provision and active employment intervention): Belgium, Denmark, Finland, France, Norway and Sweden. **Labour-emphasis type** (active employment intervention but low welfare provision): Germany and Netherland. **Welfare-emphasis type** (high welfare provision and inactive employment intervention): Canada, Japan and New Zeeland. **Market-emphasis type** (low welfare provision and inactive employment intervention): Australia, Ireland, Switzerland, UK and USA.
Kuitto (2011)	**Age-related cash benefits (**old-age and survivors' cash benefits); **Working-age benefits** (income support payments in respect of incapacity, unemployment, families and social assistance plus spending on active labour market policies); **Healthcare services** (benefits in kind), **Other service expenditure** (all social services other than health)	Agglomerative hierarchical clustering procedure (hierarchical cluster analysis, HCA) using the squared Euclidian distance as a distance measure and the Ward method as clustering algorithm is applied.	**Continental European Cluster:** Austria, Belgium, France, Germany, Netherlands, UK and Switzerland. **Southern European Cluster:** Greece, Portugal, Slovenia, Italy, Cluster, Denmark, Sweden, Finland, Iceland and Norway. **Eastern European Cluster:** Bulgaria, Estonia, Latvia, Lithuania, Romania, Poland and Slovakia. **Mixed/unclassified:** Czech Republic, Hungary, Ireland, Luxemburg and Spain.

Lauzadyte-Tutliene, Balezentis and Goculenko (2018)	**Political indicators:** the electoral activity at the national and European elections; **Economic situation:** Export (% of GDP); Import (% of GDP); Real GDP growth, %; Harmonized Consumer Price Index; **Demographic situation:** infant mortality; life expectancy; birth rate **Education:** four-year-olds in educational institutions; 20-24 years old students in tertiary education; 25-64 years old persons with at least secondary education; premature school leaving, **Labor market:** employment; youth employment; employment of the elders; workers under temporary contracts; part-time employees; self-employed; long term unemployment; unemployment rate, **Gender differences in the labour market:** the ratio of employment rates of men and women; the ratio of unemployment rates of men and women; the ratio of long term unemployment rates of men and women; the pay gap between men and women, **Living conditions:** people at risk of poverty and social exclusion; aggregated replacement rate; income inequality (S80/S20). **Government Program Variables:** Social contributions, % of GDP; Government expenditure, % of GDP; Expenditure for social protection, by function, % of the total expenditure. **Structure of Government Expenditure**	Hierarchical cluster analysis (HCA) and the Euclidean square distance as a dissimilarity measure	**(1)** Mediterranean, **(2)** the small European states, **(3)** the old European countries. **(4)** and **(5)** the Central and Eastern European countries form two separate welfare state models. The Eastern Europe welfare model consists of Lithuania, Latvia, Estonia, Bulgaria and Romania, and the Central Europe welfare model – Czech Republic, Croatia, Poland, Slovenia, Slovakia and Hungary.
Minas, Jacobson, Antoniou and McMullan (2014)	**Family**: People per Household (Eurostat, 2011) and Age of Leaving Home (Eurostat, 2009). **Economic**: Expenditure on Social Protection and General Government Contributions to Receipts of Social Protection Schemes (%GDP). **Religion**: Attendance at Religious Service at least Once a Week; **Clientelism**: Perception of Corruption as Part of Business Culture, Perception of Corruption as Major Problem	Hierarchal cluster analysis (HCA), K-means and partitioning around medoids (PAM). They are applied to the data sequentially in order to test the robustness of the clusters.	**(1)** Belgium, Austria, UK, France, Germany, Netherlands, Luxembourg. **(2)** Portugal, Cyprus, Italy, Spain, Greece, Irelan and Malta. **(3)** Sweden, Finland and Denmark.
Pfeifer (2010)	**(1)** Index of unemployment benefits generosity; replacement rates of social assistance in relation to average production worker wage **(2)** Spending on unemployment benefits and social assistance in % of GDP; spending on unemployment benefits and social assistance per recipient **(3)** Recipiency rate as fraction of unemployment rate **(4)** unemployment rate as a % of active population.	Agglomerative hierarchical methods. ward cluster analysis using the squared Euclidean distance	**Cluster 1:** Netherlands and Denmark, **Cluster 2:** Austria, Ireland, United Kingdom and Portugal**, Cluster 3**: Belgium, Germany, Spain, Finland, France and Sweden, Cluster 4: Greece and Italy.

Piotrowska and Rae (2018)	**Government Programmes, Social Situation and Political Programmes:** Total general government expenditure % of GDP; Final consumption expenditure of general government (% GDP); Social benefits paid by general government (% of GDP); Investment by institutional sectors % of GDP; Total general government revenue % of GDP; Individual Income tax Rate; Net Social contributions % of GDP; Public health spending % GDP; Research and Development expenditure; Hospital Beds; Education spending % of GDP; Unemployment Rate; Long-Term Unemployment; GDP Growth Rate; Employment Rate; Female Employment Rate; Infant Mortality Rate; Fertility Rate; Inflation Rate; Life expectancy; Age first child born; Voting turnout; **Social stratification:** Risk of poverty; Material deprivation; Housing Deprivation and Income inequality	Hierarchical cluster analysis (HCA). The F test (for symmetric distributions) and the Kruskal-Wallis test (when skewness exceeded |1|) were used to test for the differences between clusters in terms of every variable included in the cluster analysis.	The post-communist countries were divided between two clusters, although by 2014 all of the post-Communist countries (apart from Slovenia) had grouped together in one separate cluster.
Tóth, Tkáčová Y Muľová (2022)	Redistributive variables and one for socio-economic variables: Gini Index, Tax revenues, Social expenditure, Social contributions, Taxes on consumption, Taxes on labour, Taxes on capital, Property taxes, Total general government expenditure on health, Total general government expenditure on education, At-risk-of-poverty rate by the poverty threshold (% GDP) HICP inflation, Unemployment rate, Government deficit, Population density, Foreign direct investment, Old-age dependency ratio, Remittances, Secondary school enrolment, per cent of all eligible children	Hierarchical cluster analysis (HCA), K-means method,	**In 2007:** Redistribution variables: 7 clusters. Economic variables: 8 clusters. **In 2019:** Redistribution variables: 5 clusters. Economic variables: 4 clusters. See Table 4 and 5 in Tóth, Tkáčová Y Muľová (2022) for more details.
West and Nikolai (2013)	Related with number of participants at different levels of education, PISA results and public expenditure in education. See Table A1 in West and Nikolai (2013) for the exact list of indicators.	Hierarchical cluster analysis (HCA). Ward method, Euclidian distance measure.	**(1) Nordic:** Denmark, Finland, Sweden. **(2) Continental:** Austria, Belgium, Germany, Netherlands. (3) **Mediterranean:** France, Greece, Italy, Portugal, Spain. **(4) English-speaking:** Ireland, UK and USA
Yörük, Öker and Ramahlo-Tafoya (2022)	Welfare generosity and welfare effort: composite index based on qualitative and quantitative information.	Hierarchical cluster analysis (HCA), k-means and model-based clustering methods (MBC)	Institutional, neoliberal, populist and residual welfare state regimes

Source: Own elaboration

Table A3.2 Detailed list of indicators used in the cluster analysis.

Indicator	Definition	Formula
Poverty reduction of the total system	It measures how the public intervention reduces poverty level by calculating the differences in poverty rates before and after public intervention.	$\text{Poverty Rate}_{\text{market income}} - \text{Poverty Rate}_{disposable\ income}$
Average poverty reduction of benefits, taxes and SIC	It measures the average poverty reduction that can be attributed to benefits, taxes and SICs. It calculates the differences in poverty rates before and after each instrument by adding the instrument in different orders and, then, the average effect is calculated.	
Inequality redistribution of the total system	It measures how the public intervention reduces inequality level by calculating the differences in Gini index rates before and after public intervention.	$Gini\ Index_{market\ income} - Gini\ Index_{disposable\ income}$
Reynolds-Smolensky index for each kind of benefit, taxes and SICs	It measures the inequality reduction that can be attributed to each kind of benefits and to taxes and SICs. It calculates the product between the Kakwani index and the level effect	$Kakwni\ Index_{Z_i} \times \text{Level}\ effect_{Z_i}$
Inequality reduction from a "*simultaneous*" approach	It measures the redistribution of each kind of benefit, taxes and SICs "independently". It starts from a hypothetical situation without the instrument (i. e. disposable income less social assistance and housing benefits) and measure how much inequality is reduced when putting it into place.	$Gini\ Index_{(disposable\ income - Z_i)} - Gini\ Index_{disposable\ income}$
Shorrocks (1983) inequality source decomposition	It measures the average inequality contribution of the different tax benefit instruments to total inequality. That is, the contribution to overall inequality (disposable inequality) of each source of disposable income (market incomes, benefits, taxes and SIC). Based on Shorrocks Decomposition	
Extent of redistribution to different income groups (quintile)	It measures the proportion of total amount of benefits that is received by each quintile (ranked by extended income). This also measures how "progressively" benefits are distributed. For the whole system we will obtain 5 shares	$\frac{\sum_{j \in q_j} Benefits_j}{\sum_n Benefits}$
Kakwani index of each kind of benefit, taxes and SICs	It measures the relative progressivity or regressivity effect of the different kind of benefit, taxes and SIC	$Kakwani\ Index_{zi}$

Benefit mix of the total system	It measures the relative weight (proportion) of each kind of benefit in the total benefits paid on an economy.	$\frac{\sum_i Z_i}{\sum_n Benefits}$
Benefit mix of different income groups (quintile)	It measures how the relative weight (proportion) of each kind of benefit in the total benefits received varies by income group (quintile)	$\frac{\sum_{j \in qj} Z_{ij}}{\sum_j Benefits_j}$
Level effect of the different kind of benefits, taxes and SICs	It measures the importance of each kind of benefits, taxes and SICs in relation to disposable income for the economy.	$\frac{\sum_n Z_{i,n}}{\sum_n Disposable\ income}$
$Z_i = Kind\ of\ instument$: $social\ assistance, pension\ and\ health, unemployment\ and family\ and\ education\ benfetis, taxes\ and\ SICs$ $q_j = income\ quintil; j = \{1, \dots, 5\}$ $n = total\ population$		

Source: Own elaboration

Table A3.3 Cluster analysis results for 15, 20 and 30 as a dissimilarity cut point.

	AT	BE	BG	CY	CZ	DE	DK	EE	EL	ES	FI	FR	HU	IE	IT	LT	LU	LV	MT	NL	PL	PT	RO	SE	SI	SK
AT	32	1	0	0	14	5	0	0	0	0	10	0	8	9	0	3	30	0	0	7	1	2	7	15	20	15
BE	1	32	0	0	0	20	0	0	0	1	7	5	0	1	1	0	1	0	0	0	0	1	0	2	0	0
BG	0	0	32	1	1	0	0	26	0	0	7	0	0	0	0	27	0	31	0	0	1	0	1	7	1	2
CY	0	0	1	32	2	1	0	0	4	0	0	21	0	0	0	1	0	1	23	2	0	2	0	0	0	0
CZ	14	0	1	2	32	9	0	0	9	2	2	0	13	3	2	2	12	0	5	1	10	13	13	2	17	16
DE	5	20	0	1	9	32	0	0	4	3	6	2	1	6	2	0	5	0	3	0	3	10	1	6	0	0
DK	0	0	0	0	0	0	32	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0
EE	0	0	26	0	0	0	0	32	0	0	12	0	1	0	0	23	0	27	0	0	0	0	1	12	0	0
EL	0	0	0	4	9	4	0	0	32	4	0	5	7	0	2	0	2	0	4	8	17	17	6	0	2	5
ES	0	1	0	0	2	3	0	0	4	32	0	1	0	0	29	0	0	0	1	1	1	15	0	0	0	0
FI	10	7	7	0	2	6	2	12	0	0	32	3	3	7	0	5	10	7	0	1	0	1	3	27	1	1
FR	0	5	0	21	0	2	0	0	5	1	3	32	1	1	0	0	0	0	19	4	0	2	1	0	0	0
HU	8	0	0	0	13	1	0	1	7	0	3	1	32	1	0	0	6	0	6	0	11	2	30	3	9	7
IE	9	1	0	0	3	6	0	0	0	0	7	1	1	32	0	0	9	0	1	0	0	3	0	8	0	0
IT	0	1	0	0	2	2	0	0	2	29	0	0	0	0	32	1	0	0	0	0	3	12	0	0	1	1
LT	3	0	27	1	2	0	0	23	0	0	5	0	0	0	1	32	3	28	0	2	1	0	0	6	4	4
LU	30	1	0	0	12	5	0	0	2	0	10	0	6	9	0	3	32	0	0	9	0	4	5	15	18	17
LV	0	0	31	1	0	0	0	27	0	0	7	0	0	0	0	28	0	32	0	0	0	0	0	7	0	1
MT	0	0	0	23	5	3	0	0	4	1	0	19	6	1	0	0	0	0	32	2	0	4	6	0	0	1
NL	7	0	0	2	1	0	0	0	8	1	1	4	0	0	0	2	9	0	2	32	0	6	0	4	13	13
PL	1	0	1	0	10	3	0	0	17	1	0	0	11	0	3	1	0	0	0	0	32	7	11	0	6	6
PT	2	1	0	2	13	10	0	0	17	15	1	2	2	3	12	0	4	0	4	6	7	32	1	1	3	6
RO	7	0	1	0	13	1	0	1	6	0	3	1	30	0	0	0	5	0	6	0	11	1	32	3	9	7
SE	15	2	7	0	2	6	2	12	0	0	27	0	3	8	0	6	15	7	0	4	0	1	3	32	4	3
SI	20	0	1	0	17	0	0	0	2	0	1	0	9	0	1	4	18	0	0	13	6	3	9	4	32	27
SK	15	0	2	0	16	0	0	0	5	0	1	0	7	0	1	4	17	1	1	13	6	6	7	3	27	32

Source: Own elaboration. Results from HCA analysis for a cut point of 15 points.

	AT	BE	BG	CY	CZ	DE	DK	EE	EL	ES	FI	FR	HU	IE	IT	LT	LU	LV	MT	NL	PL	PT	RO	SE	SI	SK
AT	32	1	0	0	17	6	0	0	1	1	11	0	10	12	0	3	30	0	1	15	3	4	8	16	23	18
BE	1	32	0	1	0	20	0	3	0	6	10	8	1	2	7	0	1	0	0	2	0	4	1	5	0	0
BG	0	0	32	2	1	0	0	27	0	0	9	0	2	0	0	27	0	31	1	0	1	0	3	9	1	2
CY	0	1	2	32	2	1	0	1	5	0	0	21	0	1	0	2	0	2	23	4	0	3	0	0	0	0
CZ	17	0	1	2	32	10	0	0	10	6	3	0	14	9	6	2	15	0	5	7	12	14	14	4	18	17
DE	6	20	0	1	10	32	0	3	5	9	10	3	2	9	8	0	6	0	3	1	4	14	1	10	1	1
DK	0	0	0	0	0	0	32	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0
EE	0	3	27	1	0	3	0	32	0	0	13	1	3	0	0	24	0	28	2	0	0	0	3	13	0	0
EL	1	0	0	5	10	5	0	0	32	10	0	6	10	2	8	0	3	0	6	8	18	20	9	1	2	5
ES	1	6	0	0	6	9	0	0	10	32	2	1	0	2	29	0	1	0	1	1	13	19	0	1	0	1
FI	11	10	9	0	3	10	2	13	0	2	32	4	4	9	1	7	11	9	3	3	0	3	4	27	4	4
FR	0	8	0	21	0	3	0	1	6	1	4	32	2	1	0	0	0	0	19	6	0	3	2	1	0	0
HU	10	1	2	0	14	2	0	3	10	0	4	2	32	7	0	2	8	2	7	1	15	4	30	5	11	9
IE	12	2	0	1	9	9	0	0	2	2	9	1	7	32	1	0	12	0	6	0	1	6	5	9	4	5
IT	0	7	0	0	6	8	0	0	8	29	1	0	0	1	32	1	0	0	0	0	15	16	0	0	1	2
LT	3	0	27	2	2	0	0	24	0	0	7	0	2	0	1	32	3	28	1	3	1	0	2	8	4	4
LU	30	1	0	0	15	6	0	0	3	1	11	0	8	12	0	3	32	0	1	17	1	6	6	16	21	20
LV	0	0	31	2	0	0	0	28	0	0	9	0	2	0	0	28	0	32	1	0	0	0	2	9	0	1
MT	1	0	1	23	5	3	0	2	6	1	3	19	7	6	0	1	1	1	32	4	1	5	7	3	0	1
NL	15	2	0	4	7	1	0	0	8	1	3	6	1	0	0	3	17	0	4	32	0	6	1	6	19	18
PL	3	0	1	0	12	4	0	0	18	13	0	0	15	1	15	1	1	0	1	0	32	12	15	1	7	6
PT	4	4	0	3	14	14	0	0	20	19	3	3	4	6	16	0	6	0	5	6	12	32	3	4	3	6
RO	8	1	3	0	14	1	0	3	9	0	4	2	30	5	0	2	6	2	7	1	15	3	32	4	11	9
SE	16	5	9	0	4	10	2	13	1	1	27	1	5	9	0	8	16	9	3	6	1	4	4	32	8	7
SI	23	0	1	0	18	1	0	0	2	0	4	0	11	4	1	4	21	0	0	19	7	3	11	8	32	27
SK	18	0	2	0	17	1	0	0	5	1	4	0	9	5	2	4	20	1	1	18	6	6	9	7	27	32

Source: Own elaboration. Results from HCA analysis for a cut point of 20 points.

	AT	BE	BG	CY	CZ	DE	DK	EE	EL	ES	FI	FR	HU	IE	IT	LT	LU	LV	MT	NL	PL	PT	RO	SE	SI	SK
AT	32	16	22	18	26	16	4	21	15	19	24	18	23	24	18	23	32	22	20	25	17	19	23	25	29	29
BE	16	32	23	16	19	31	1	24	20	26	22	20	18	18	27	22	16	23	17	17	25	25	18	21	17	17
BG	22	23	32	20	23	22	2	31	16	27	25	22	22	19	26	31	22	32	21	21	22	22	22	26	25	25
CY	18	16	20	32	21	15	2	19	22	17	13	28	18	15	16	21	18	20	27	25	14	20	18	14	21	21
CZ	26	19	23	21	32	20	1	22	21	22	20	19	29	24	21	24	26	23	24	23	23	25	29	19	29	29
DE	16	31	22	15	20	32	1	23	21	25	22	19	19	19	26	21	16	22	18	17	26	26	19	21	17	17
DK	4	1	2	2	1	1	32	3	3	2	7	2	2	6	3	2	4	2	1	1	4	1	2	7	2	2
EE	21	24	31	19	22	23	3	32	15	26	26	21	21	18	27	30	21	31	20	20	23	21	21	27	24	24
EL	15	20	16	22	21	21	3	15	32	21	13	22	20	14	20	17	15	16	23	20	24	26	20	12	18	18
ES	19	26	27	17	22	25	2	26	21	32	22	17	19	17	31	28	19	27	16	18	27	27	19	21	22	22
FI	24	22	25	13	20	22	7	26	13	22	32	17	19	21	23	24	24	25	16	19	21	18	19	31	21	21
FR	18	20	22	28	19	19	2	21	22	17	17	32	18	17	16	21	18	22	27	25	14	20	18	18	19	19
HU	23	18	22	18	29	19	2	21	20	19	19	18	32	23	18	21	23	22	23	20	22	22	32	18	26	26
IE	24	18	19	15	24	19	6	18	14	17	21	17	23	32	16	18	24	19	18	17	16	20	23	20	21	21
IT	18	27	26	16	21	26	3	27	20	31	23	16	18	16	32	27	18	26	15	17	28	26	18	22	21	21
LT	23	22	31	21	24	21	2	30	17	28	24	21	21	18	27	32	23	31	20	22	23	23	21	25	26	26
LU	32	16	22	18	26	16	4	21	15	19	24	18	23	24	18	23	32	22	20	25	17	19	23	25	29	29
LV	22	23	32	20	23	22	2	31	16	27	25	22	22	19	26	31	22	32	21	21	22	22	22	26	25	25
MT	20	17	21	27	24	18	1	20	23	16	16	27	23	18	15	20	20	21	32	27	17	21	23	17	23	23
NL	25	17	21	25	23	17	1	20	20	18	19	25	20	17	17	22	25	21	27	32	16	20	20	20	26	26
PL	17	25	22	14	23	26	4	23	24	27	21	14	22	16	28	23	17	22	17	16	32	26	22	20	20	20
PT	19	25	22	20	25	26	1	21	26	27	18	20	22	20	26	23	19	22	21	20	26	32	22	17	22	22
RO	23	18	22	18	29	19	2	21	20	19	19	18	32	23	18	21	23	22	23	20	22	22	32	18	26	26
SE	25	21	26	14	19	21	7	27	12	21	31	18	18	20	22	25	25	26	17	20	20	17	18	32	22	22
SI	29	17	25	21	29	17	2	24	18	22	21	19	26	21	21	26	29	25	23	26	20	22	26	22	32	32
SK	29	17	25	21	29	17	2	24	18	22	21	19	26	21	21	26	29	25	23	26	20	22	26	22	32	32

Source: Own elaboration. Results from HCA analysis for a cut point of 30 points.

Table A3.4 Result of cluster analysis. Significative coincidence (65%)

	AT	BE	BG	CY	CZ	DE	DK	EE	EL	ES	FI	FR	HU	IE	IT	LT	LU	LV	MT	NL	PL	PT	RO	SE	SI	SK
AT	100.0%	6.3%	12.5%	9.4%	56.3%	21.9%	0.0%	6.3%	9.4%	3.1%	34.4%	3.1%	31.3%	46.9%	0.0%	18.8%	100.0%	9.4%	9.4%	59.4%	12.5%	18.8%	28.1%	50.0%	78.1%	71.9%
BE	6.3%	100.0%	9.4%	3.1%	3.1%	62.5%	0.0%	18.8%	12.5%	34.4%	43.8%	28.1%	15.6%	15.6%	37.5%	3.1%	6.3%	9.4%	3.1%	6.3%	15.6%	21.9%	15.6%	28.1%	3.1%	3.1%
BG	12.5%	9.4%	100.0%	34.4%	15.6%	18.8%	0.0%	87.5%	3.1%	21.9%	34.4%	31.3%	18.8%	9.4%	25.0%	87.5%	12.5%	96.9%	28.1%	6.3%	9.4%	9.4%	15.6%	37.5%	12.5%	12.5%
CY	9.4%	3.1%	34.4%	100.0%	15.6%	9.4%	3.1%	34.4%	31.3%	6.3%	12.5%	71.9%	15.6%	12.5%	3.1%	34.4%	9.4%	34.4%	81.3%	31.3%	6.3%	21.9%	15.6%	15.6%	6.3%	9.4%
CZ	56.3%	3.1%	15.6%	15.6%	100.0%	34.4%	0.0%	9.4%	40.6%	18.8%	9.4%	3.1%	56.3%	40.6%	18.8%	15.6%	56.3%	12.5%	18.8%	37.5%	46.9%	50.0%	53.1%	12.5%	68.8%	75.0%
DE	21.9%	62.5%	18.8%	9.4%	34.4%	100.0%	0.0%	28.1%	31.3%	43.8%	43.8%	18.8%	18.8%	37.5%	40.6%	12.5%	21.9%	18.8%	18.8%	15.6%	31.3%	53.1%	15.6%	43.8%	15.6%	15.6%
DK	0.0%	0.0%	0.0%	3.1%	0.0%	0.0%	100.0%	0.0%	3.1%	0.0%	6.3%	3.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	6.3%	0.0%	0.0%
EE	6.3%	18.8%	87.5%	34.4%	9.4%	28.1%	0.0%	100.0%	3.1%	25.0%	43.8%	31.3%	12.5%	6.3%	28.1%	81.3%	6.3%	90.6%	28.1%	3.1%	6.3%	9.4%	9.4%	46.9%	6.3%	6.3%
EL	9.4%	12.5%	3.1%	31.3%	40.6%	31.3%	3.1%	3.1%	100.0%	34.4%	3.1%	31.3%	46.9%	15.6%	28.1%	3.1%	9.4%	3.1%	40.6%	34.4%	68.8%	68.8%	43.8%	6.3%	25.0%	28.1%
ES	3.1%	34.4%	21.9%	6.3%	18.8%	43.8%	0.0%	25.0%	34.4%	100.0%	12.5%	9.4%	3.1%	12.5%	90.6%	18.8%	3.1%	21.9%	12.5%	6.3%	43.8%	59.4%	3.1%	9.4%	3.1%	6.3%
FI	34.4%	43.8%	34.4%	12.5%	9.4%	43.8%	6.3%	43.8%	3.1%	12.5%	100.0%	31.3%	18.8%	34.4%	9.4%	28.1%	34.4%	34.4%	18.8%	15.6%	0.0%	12.5%	18.8%	84.4%	15.6%	15.6%
FR	3.1%	28.1%	31.3%	71.9%	3.1%	18.8%	3.1%	31.3%	31.3%	9.4%	31.3%	100.0%	12.5%	12.5%	3.1%	28.1%	3.1%	31.3%	68.8%	31.3%	0.0%	18.8%	12.5%	21.9%	0.0%	0.0%
HU	31.3%	15.6%	18.8%	15.6%	56.3%	18.8%	0.0%	12.5%	46.9%	3.1%	18.8%	12.5%	100.0%	43.8%	0.0%	15.6%	31.3%	15.6%	31.3%	18.8%	50.0%	31.3%	96.9%	18.8%	46.9%	50.0%
IE	46.9%	15.6%	9.4%	12.5%	40.6%	37.5%	0.0%	6.3%	15.6%	12.5%	34.4%	12.5%	43.8%	100.0%	6.3%	6.3%	46.9%	6.3%	28.1%	6.3%	12.5%	28.1%	40.6%	34.4%	28.1%	31.3%
IT	0.0%	37.5%	25.0%	3.1%	18.8%	40.6%	0.0%	28.1%	28.1%	90.6%	9.4%	3.1%	0.0%	6.3%	100.0%	21.9%	0.0%	25.0%	3.1%	3.1%	50.0%	50.0%	0.0%	6.3%	6.3%	9.4%
LT	18.8%	3.1%	87.5%	34.4%	15.6%	12.5%	0.0%	81.3%	3.1%	18.8%	28.1%	28.1%	15.6%	6.3%	21.9%	100.0%	18.8%	90.6%	25.0%	15.6%	6.3%	6.3%	12.5%	34.4%	18.8%	15.6%
LU	100.0%	6.3%	12.5%	9.4%	56.3%	21.9%	0.0%	6.3%	9.4%	3.1%	34.4%	3.1%	31.3%	46.9%	0.0%	18.8%	100.0%	9.4%	9.4%	59.4%	12.5%	18.8%	28.1%	50.0%	78.1%	71.9%
LV	9.4%	9.4%	96.9%	34.4%	12.5%	18.8%	0.0%	90.6%	3.1%	21.9%	34.4%	31.3%	15.6%	6.3%	25.0%	90.6%	9.4%	100.0%	28.1%	6.3%	6.3%	9.4%	12.5%	37.5%	9.4%	9.4%
MT	9.4%	3.1%	28.1%	81.3%	18.8%	18.8%	0.0%	28.1%	40.6%	12.5%	18.8%	68.8%	31.3%	28.1%	3.1%	25.0%	9.4%	28.1%	100.0%	28.1%	12.5%	31.3%	31.3%	21.9%	3.1%	6.3%
NL	59.4%	6.3%	6.3%	31.3%	37.5%	15.6%	0.0%	3.1%	34.4%	6.3%	15.6%	31.3%	18.8%	6.3%	3.1%	15.6%	59.4%	6.3%	28.1%	100.0%	18.8%	28.1%	18.8%	25.0%	65.6%	59.4%
PL	12.5%	15.6%	9.4%	6.3%	46.9%	31.3%	0.0%	6.3%	68.8%	43.8%	0.0%	0.0%	50.0%	12.5%	50.0%	6.3%	12.5%	6.3%	12.5%	18.8%	100.0%	56.3%	46.9%	3.1%	34.4%	37.5%
PT	18.8%	21.9%	9.4%	21.9%	50.0%	53.1%	0.0%	9.4%	68.8%	59.4%	12.5%	18.8%	31.3%	28.1%	50.0%	6.3%	18.8%	9.4%	31.3%	28.1%	56.3%	100.0%	28.1%	15.6%	28.1%	31.3%
RO	28.1%	15.6%	15.6%	15.6%	53.1%	15.6%	0.0%	9.4%	43.8%	3.1%	18.8%	12.5%	96.9%	40.6%	0.0%	12.5%	28.1%	12.5%	31.3%	18.8%	46.9%	28.1%	100.0%	15.6%	43.8%	46.9%
SE	50.0%	28.1%	37.5%	15.6%	12.5%	43.8%	6.3%	46.9%	6.3%	9.4%	84.4%	21.9%	18.8%	34.4%	6.3%	34.4%	50.0%	37.5%	21.9%	25.0%	3.1%	15.6%	15.6%	100.0%	28.1%	25.0%
SI	78.1%	3.1%	12.5%	6.3%	68.8%	15.6%	0.0%	6.3%	25.0%	3.1%	15.6%	0.0%	46.9%	28.1%	6.3%	18.8%	78.1%	9.4%	3.1%	65.6%	34.4%	28.1%	43.8%	28.1%	100.0%	93.8%
SK	71.9%	3.1%	12.5%	9.4%	75.0%	15.6%	0.0%	6.3%	28.1%	6.3%	15.6%	0.0%	50.0%	31.3%	9.4%	15.6%	71.9%	9.4%	6.3%	59.4%	37.5%	31.3%	46.9%	25.0%	93.8%	100.0%

Source: Own elaboration. Results from HCA analysis for a cut point of 25 points.

Chapter 4

How the EU's welfare state systems contribute to the inequality-poverty-growth dynamic relationship?

Abstract

This paper analyses the dynamic relationships between income inequality, monetary poverty and economic growth for a sample of different European Welfare states over the period 2003-2019. To do so, we have used a novel classification proposed in the third chapter of the thesis which classify the countries according to the distribution of its resources. This classification proposes 7 different clusters of welfare states. Then, a Granger causal analysis for the period 2003-2019 is performed for each cluster. The econometric approach relies on the work of Dumitrescu and Hurlin (2012) and Emirmahmutoglu and Kose (2011) who proposed a strategy to compute panel data estimators based on the individual information of the cross-sectional units -countries- conforming each subgroup. Our results show that there is a high degree of heterogeneity in terms of relationships depending on the cluster of countries we examine. Despite this, it is also possible to find certain features or regularities that are repeated with a certain frequency. Perhaps most striking is that only in one of the groups is there a direct relationship between inequality and economic growth. In contrast, the direct relationship between economic growth and poverty is significant in 5 of the 7 groups analysed. In 3 of the 5 groups analysed, growth not only does not reduce poverty, but increases it. In these groups of economies, pro-rich economic growth seems to be occurring. Likewise, in 2 of the 5, poverty precedes economic growth, which would be in line with the efficiency thesis.

1. Introduction

The role of welfare states in mediating the causal link between distributional indicators has been of interest since the very origins of the welfare state literature. In the seminal work of Esping-Andersen (1990) Socio-democratic regimes found in Nordic countries were associated with lower levels of income inequality and greater poverty alleviation through universalistic principles and higher coverage of benefits whereas Liberal regimes, mostly developed in Anglo-Saxon countries, characterised by lower levels of social protection, stricter eligibility rules and means-tested assistance, were associated with higher levels of income inequality. Conservative regimes of continental Europe were found somewhere in the middle, with most part of their social protection systems arranged through social insurance contributions.

Subsequent extensions proposing new welfare state regimes in European countries identified the Mediterranean model[41] and the Central and Eastern European Model (Ferrera, 1996; Fenger, 2007, among others). The former is characterized by higher levels of inequality due to the fact that social protection is associated to the role of the individual in the labour market, which lead to a segmented protection system, and with a notable role for the family in complementing social protection of those outside the public system. The latter has been usually seen as a highly influenced by the institutional path dependency derived from the post-communist development of their welfare states and usually tend to present worse distributive outcomes than other countries in Europe.

Similarly, studies related to the welfare state have also addressed the role of the welfare state in relation to economic growth. In general, the two predominant theoretical hypotheses have been those that associate the welfare state with a negative effect on economic growth and those that, on the contrary, associate it with a positive effect. The former, the so-called *efficiency thesis* argues that a greater degree of social assistance would interfere with market activities through disincentives to labour, savings and investment and hence, therefore, would undermine economic growth. Likewise, the public expenditure needed to finance social welfare would also be problematic to economic growth. On the other hand, the latter, which is known as *compensation thesis* argues that in the context of globalisation, welfare state should expand in order to compensate the worsening of distributive outcomes.

In this respect, the 2008 financial crisis and the implementation of austerity policies marked a major turning point in the debate on whether the different welfare states succeeded in impacting social welfare and the dynamics of the different distributive indicators. With most economies

[41] Although some authors agree that mediterranean countries are a subgroup of the Conservative regimes due the role of Social Insurance Contributions, the differences in their respective labor markets lead us to differentiate between the two types of welfare systems.

suffering from economic recession and a generalized worsening of most social welfare and distributive indicators, concerns arise as to whether public social protection systems were also in decline.

However, although there have been numerous studies focused on analysing the relationship between, on the one hand, income distribution and, on the other hand, economic growth, the debate remains open. In this regard, the need to take into account the homogeneity of the samples has been pointed out, emphasizing the homogeneity of the institutional characteristics of the countries (Borge and Rattsø, 2004; Claveria and Soric, 2024)

In this regard, the aim of this paper is to address this issue and to contribute to the empirical study of whether different patterns of causality between economic growth, income inequality and monetary poverty can be found when European countries are clustered according to their welfares system. Following the results of the first and third chapter of this thesis, we first group the country according to the classification proposed there and then, perform a panel Granger causality analysis. With this study, we aim to contribute on the one hand to the empirical literature that analyse the distributive outcomes of welfare state systems and, on the other, to the studies of whether public social systems have a negative effect or positive effect on economic growth. In this regards, causal discovery algorithms and causal maps provide a useful and powerful tool for analysing causal links between variables potentially endogenous. One of the novelties of this study lies in the fact that both the classification used, and the causality analysis carried out take a *data-driven* approach. and, furthermore, both refer to the same period.

The aforementioned classification is based on *how* the public systems allocates their resources among the population, rather than focusing on the distributional *outcomes* following a particular mix of social policies. Since the same distributional patterns may be obtained by applying different sets of social policies, welfare state diversity and distributional results are thus independently defined, which is particularly interesting for our purposes here. Additional advantages of this taxonomy lie in overcoming the lack of dynamic structure usually found on the literature of welfare state taxonomies and avoiding the usual geographical bias found on standard classifications as the one proposed in Esping-Andersen (1990) and subsequent extensions.

The rest of the paper is structured as follows. In the next section we conduct a brief literature review concerning this topic. In section three we describe our data and the empirical approach. Section four present the main results derived from the analysis. Finally, section five concludes.

2. Literature review

The complex relationship between economic growth and income distribution have been explored from different approaches. When distinguishing between different country characteristics, the

most common practice has been to separate developing from developed economies on the one hand, or to carry out the analysis according to geographic zones on the other. Among others, Dawson (1997) analyse the relationship between economic growth and income inequality for 36 less developed countries, finding that the relationship presents an inverted "U" shape. Li and Zou (1998) cover 46 advanced and developing countries finding a positive association between income inequality and economic growth. In Tanninen (1999) a negative relationship between inequality and economic growth is found using a sample of 49 countries. Forbes (2000) include in his analysis 45 countries also finding a positive effect from income inequality to economic growth. Barro (2000) carries out their analysis covering up to 76 different countries -including developed and developing economies- and failing to find a strong relationship among income inequality and rates of growth. On the contrary, Ravallion (2014) performs a study also focused on developing countries and finds that inequality tends to diminish economic growth. This has the effect of hindering the further reduction of inequality. Castelló-Climent (2010) distinguishes according to the level of development of the region and finds that the effect is negative in middle- and low-income countries. Finally, Brida et al (2020) perform a Granger causality analysis between economic growth and inequality for a sample of countries and also obtain that the relationships change with the stage of development.

Although the predominant focus in the literature on the welfare state has been the study of the institutional characteristics of the different European welfare states, the causal link between distributive variables and economic growth and the effectiveness of the social programs that comprise them in achieving social objectives has received somewhat less attention. Particularly, the most common approach has been to compare inequality and poverty across countries to seek for a common trend based on their traditional classifications in welfare state regimes.

Korpi and Palme (1998) analyse how countries perform in terms of inequality and poverty rate distinguishing by the kind of welfare state they belong to – encompassing, corporatist, basic security and targeted- finding that inequality and poverty is higher in countries with a targeted and basic security welfare state models such as Australia, Switzerland, United Kingdom, United States and Canada and lower in encompassing systems as Finland, Norway and Sweeden. Netherland, who theoretically belongs to the basic security groups, resemble more to the encompassing system. Ferragina et al. (2006) analyse for 14 EU countries how they cluster in terms of inequality and poverty rates overall and by age groups as well as other labour market variables, finding that, except Germany and UK that are group together, the rest of results aligns with previous classifications. Kammer et al. (2012) perform a cluster analysis of 15 European countries based on various inequality and redistribution measures and find that most countries classify according to the taxonomy proposed by Esping-Andersen (1990). Nordic countries present lower levels of inequality and higher levels of redistribution while Mediterranean and

Anglo-Saxon countries behave just the opposite. Continental European countries are found in the middle and Belgium and Netherland behave as hybrid cases.

3. Empirical analysis

3.1 Data and methodological issues

In our work, we provide a test for investigating dynamics causal relationship among income inequality, monetary poverty and economic growth for the period 2003-2019 for 7 cluster of 21 European countries classified according to the welfare state revision proposed in the Chapter 3 of this thesis. Our database is composed of the following variables: (i) Gini index as a proxy of income inequality; (ii) anchored poverty rate as a proxy of monetary poverty (iii) growth of rate of real GDP per capita. Both poverty and inequality indicators are calculated for the same income definition. This is gross equivalized household income. Gross income definition includes incomes derived from the market as well as different benefits coming from the public system. Both indices are calculated at the household level and equivalized using OECD modified equivalence scale. Economic growth data is directly obtained from Eurostat.

To do so, we use the econometric approach proposed in in the Chapter 1 of this thesis to address Granger causality with VAR models in a panel data environment. The approach essentially consists in the computation of aggregated measures for each different cluster or group based on the information of every cross-sectional unit belonging to that group. This econometric approach is then combined with the application of the PC algorithm- see Figure X for a representation of the algorithm- and the results are represented in the lines of the causal graph-theoretic method (Lauritzen and Richardson (2002), Demiralp and Hoover (2003), Eichler (2007)).

The groups analysed are conformed in the next way. The first cluster consist of Sweden and Finland; the second cluster is formed by Estonia, Latvia, Lithuania and Bulgaria; the third cluster consists of Hungary and Romania; the four cluster corresponds to Italy and Spain, the fifth cluster is formed by Poland, Greece and Portugal; The sixth cluster is formed by Malta, Cyprus and France. Finally, the seventh cluster is formed by Luxemburg, Austria, Czech Republic, Slovenia and Slovakia.

The benchmark specification proposed here is the next multivariate vector autoregressive panel model (P-VAR) for each cluster (*g)* limited to the main variables of the study:

$$Y_{it} = \mu i + \Phi_{i(\tau i)} Y_{i,t-\tau} + \varepsilon_{it} \quad i = 1, \dots, N;\ t = 1, \dots, T \tag{1}$$

Where Y_{it} is the vector of *(p)* endogenous variables -income inequality, monetary poverty and economic growth- of a country *i* belonging to a cluster (*g)* in a year *t*. The index *i* shows each cross-sectional unit, and *t* denotes the periods. $\Phi_{i,1}, \dots, \Phi_{i,\tau_i}$ are *(p x p)* matrices of parameters.

ε_{it} is ($p\ x\ 1$) of error terms, which are independently and identically distributed *(iid)*. Finally, τi is the order of the autoregressive process.

In order to compute the aggregated indicator of each cluster *(g)* we apply the following transformation to the cross-sectional information. (i) Based on the Wald's test for Granger non-causality, we carry out Fisher's (1923) transformation of the *p-values*. From this synthetic indicator (λ) we are able to determine is a relationship between variables is significant for the entire sample.

$$\lambda = -2\sum \ln p_i \tag{2}$$

This test has a chi-square distribution with 2*N* degrees of freedom.

(ii) Subsequently, we follow David (1949) who proposed an estimation of a comprehensive measure to obtain the dominant correlation among cross-sectional individuals, which provides insights into the direction and strength of the connection[42].

Finally, all this information together can be expressed along the lines of the causal maps literature and causal discovery algorithm.

3.2 Descriptive analysis

From its foundation and throughout the various stages of its evolution, the European Union has consistently incorporated references to different social objectives regarding to income distribution in its action plans – from the Treaty on the Functioning of the European Union to the European Pillar of Social Rights (ESPR)-. The progress toward achieving these objectives has been far from uniform, neither among the different member states nor over time. The various macroeconomic events that occurred between 2003 and 2019, such as the Great Recession, the Sovereign Debt Crisis suffered by some European countries, and the subsequent period of austerity, have influenced the ability of different governments to address social needs. In this regard, this section we conduct an exploratory analysis of the main indicators for the different welfare state groups, in order to anticipate the results presented in the following section.

Figure 4.1 presents the initial and final values of inequality, poverty, and economic growth indicators respectively for all groups in addition of the countries that were not clustered. Regarding inequality, as represented in the upper panel, it can be observed at first glance that most groups and countries included exhibit somewhat higher levels in 2019 compared to 2006, indicating a slight deterioration in gross income distribution over the period. The clearest

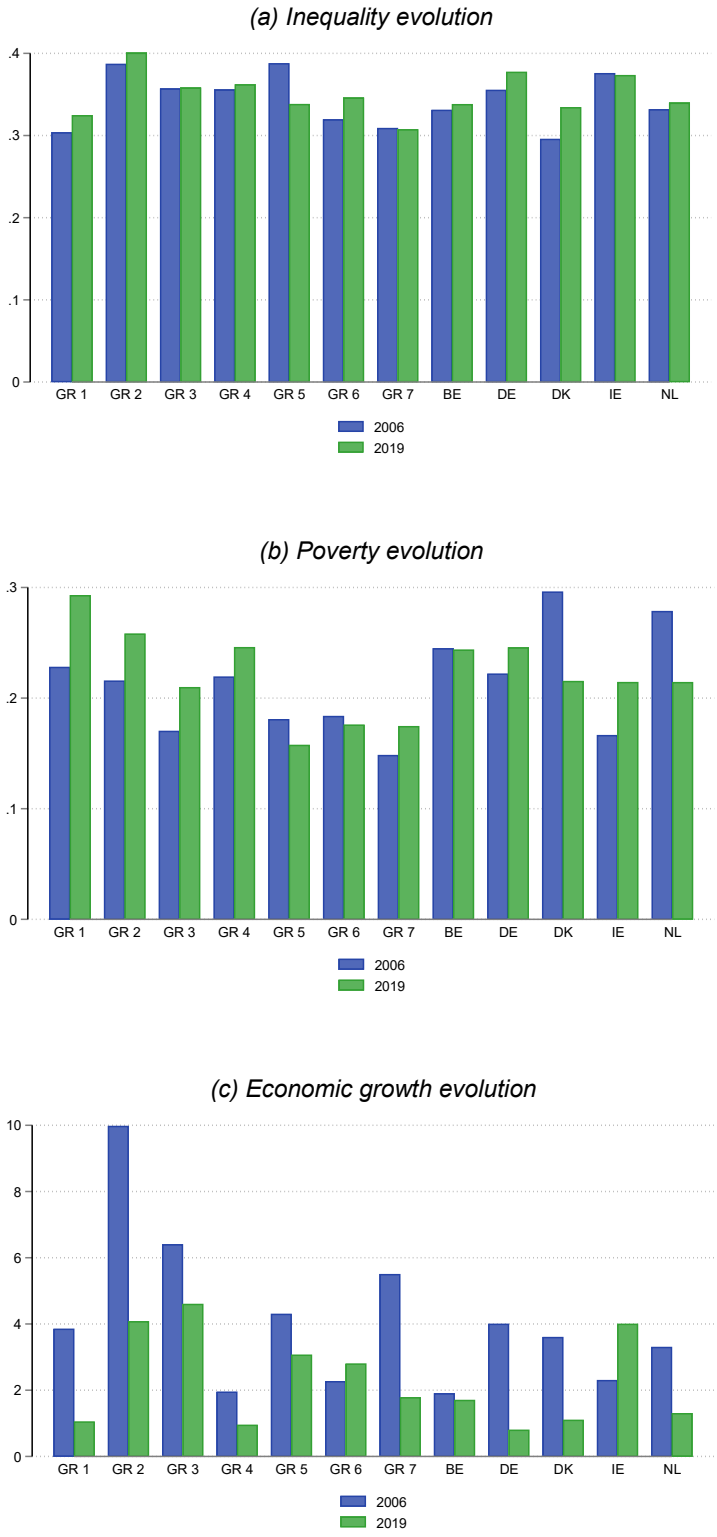
[42] For a more detailed description of the procedure, see Chapter 1.

exception to this trend is represented by G5 of countries -comprising Greece, Portugal, and Poland- where average inequality has decreased by approximately 5 points. Similarly, clusters G3, G4, and G7, as well as Belgium, Ireland, and Netherlands, have experienced very little variation in their final values compared to the initial ones. Broadly speaking, it appears that over the 13-year period, there have been no substantial improvements in reducing inequality: either a slight deterioration or lack of progress has occurred. Finally, all cluster and countries show Gini indices ranging between 0.3 and 0.4 points, so the variation between cases is not particularly pronounced. Nevertheless, the groups with the lowest levels of inequality are G1 and G7, while those with the highest levels are G2, Germany, and Ireland.

If we now focus on the variation related to poverty -represented in the middle panel-, the situation is similar to that described above, although some differences can be observed. Most groups of countries also show higher levels of poverty at the end of the period. However, the increases are of a greater magnitude, particularly in the case of G1 – Finland and Sweeden-. On the other hand, we find cases such as Denmark and Netherlands, where there has been a significant improvement in poverty levels, with reductions of approximately 8 points. At an aggregate level, the only clusters of countries that manage to reduce their poverty levels are G5 - Greece, Portugal, and Poland - and G6 -Cyprus, France and Malta. Regarding the inter-cluster comparison, the groups with the lowest poverty levels were G5, G6, and G7, while those with higher levels were G1, G2, and G4. The case of G1 is particularly notable, as it consists of Nordic countries, which are traditionally associated with lower poverty levels in terms of disposable income. This suggests the significant role their public systems play in correcting the high poverty levels observed in gross income.

Finally, the lower panel, which illustrates the evolution of economic growth rates, reveals a remarkable degree of homogeneity among the various groups and countries analysed. All of them experience a slowdown in their growth rates around 2019. However, there is a notable exception: Ireland. This country not only avoids the general trend of deceleration but also manages to reverse the situation, nearly doubling its growth rate compared to that of 2006. However, Ireland often represents an outlier in terms of economic growth, due to the unique idiosyncrasies of its economic development model. The clusters that have experienced the greatest reduction in their growth rates are G1 -Finland and Sweeden-; G2 -Bulgaria, Estonia, Latvia, Lithuania-; and G7 - Austria, Luxembourg, Czech Republic, Slovenia and Slovakia-. In the case of G2, given that these countries participated in the fifth and sixth EU enlargements, their growth levels during those years were also relatively exceptional.

Figure 4.1 Evolution of the income inequality, monetary poverty and economic growth: 2006-2019.



Source: Own elaboration from EUSILC data

However, to achieve a deeper understanding of the complex phenomenon, it is necessary to consider the dynamics of the variables under study. For this reason, in Figure 4.2 we have shown

the evolution over time of each of the countries in each group as well as the group average. In this way, we can observe not only how the individual cases have evolved, but also the degree of group cohesion. In this sense, in terms of inequality -represented in the upper panel- we can observe an evolution characterized by a high degree of heterogeneity, both in terms of the temporal dynamics and the cohesion of the clusters.

Thus, G1, composed of Sweeden and Finland, exhibits higher overall levels of cohesion than those of most groups. At the beginning of the period -when the greatest divergence is observed- the Gini index fluctuated between approximately 0.28 and 0.32. Since then, the difference between the values has progressively diminished, nearly converging at 0.325, primarily due to the increase in inequality experienced by Sweeden. In terms of average evolution, it is observed that, since 2009, inequality has maintained a nearly constant upward trajectory. G4, composed of Italy and Spain, also demonstrates a high degree of group cohesion. In this case, the period of greatest divergence occurs between 2012 and 2016, during which Spain shows a Gini index of 0.38 and Italy of 0.36. Moreover, in 2016, not only is there a return to convergence, but also a shift in trend towards decreasing inequality. The last group exhibiting a significant degree of group cohesion is G6, composed of Cyprus, France and Malta. In this regard, these countries show a relatively similar trajectory throughout the period, maintaining relatively stable Gini index values. The only exception occurs in Cyprus between 2010 and 2017, during which inequality rises by 6 points although by the end of the period it had recovered the initial levels.

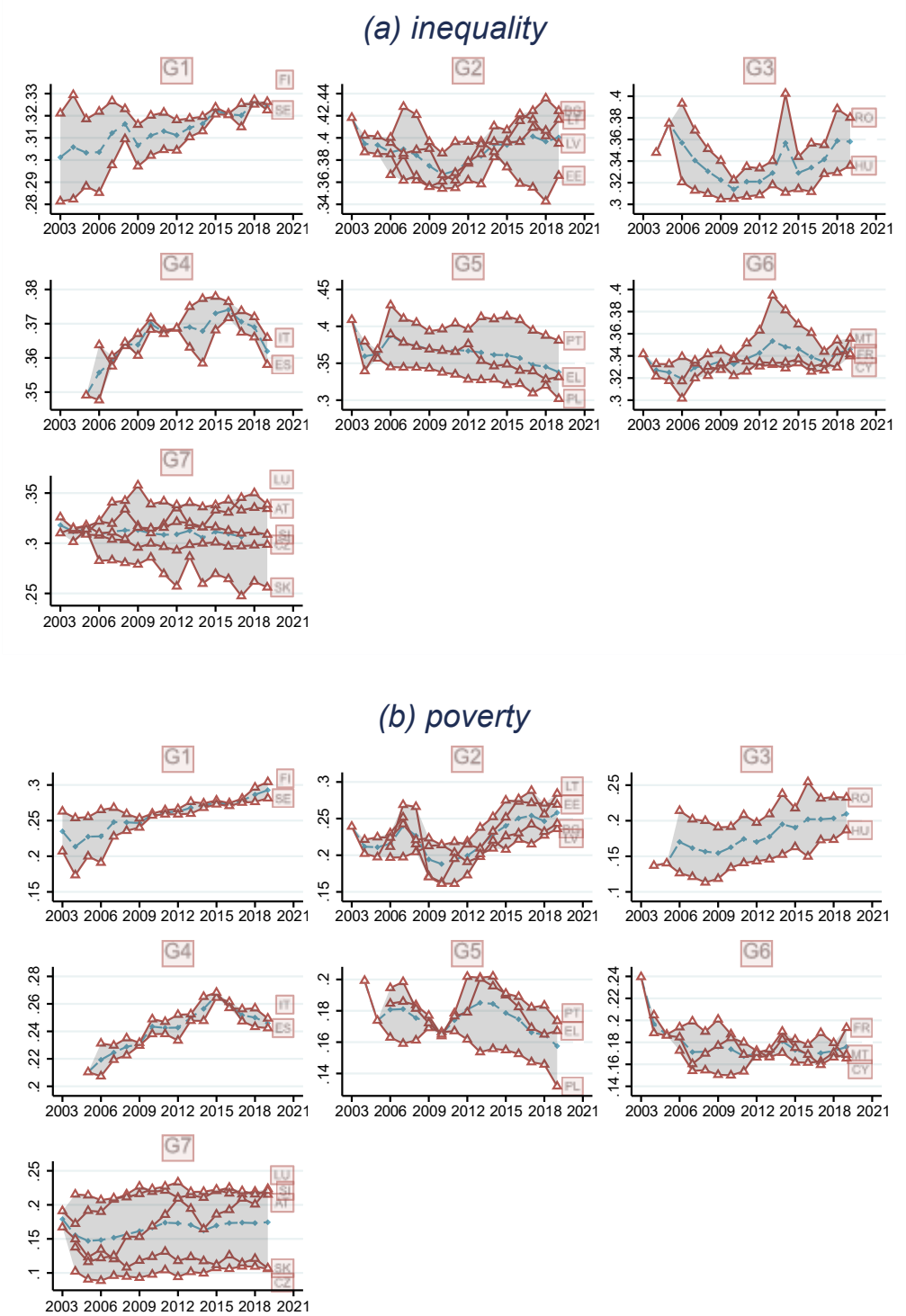
The groups exhibiting the lowest levels of group cohesion are G2, G5, and G7. In all cases, dispersion tends to peak at the end of the period, with the difference between maximum and minimum values of the Gini index being approximately 10 points. In the case of G2, it appears that, in 2019 this gap is beginning to close, as the difference between the minimum value -pertaining to Estonia- and the maximum -Bulgaria- starts to decrease. G5, in turn, maintains an apparently stable level of cohesion. Similarly, all the countries that compose it have experienced sustained reductions in inequality levels, starting practically from 2006. Lastly, regarding G3, it maintains a moderate level of cohesion, with a difference of approximately 4 points. However, between 2012 and 2015, this gap widens sharply, reaching a 10-point difference, primarily due to the increase in inequality experienced by Romania.

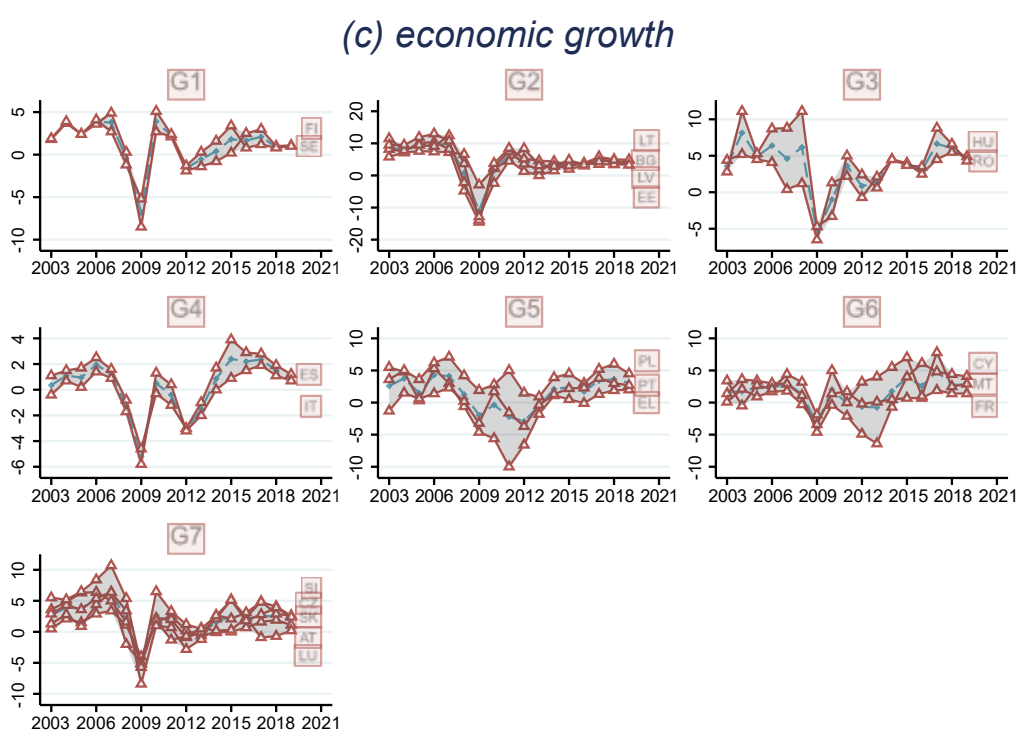
In the case of poverty, represented in the central panel, group cohesion appears to be even stronger. In this regard, clusters G1, and G4 as well as G2 and G6 show a high degree of similarity, especially the first two in which the countries virtually coincide in their poverty levels at the end of the period. On the contrary, G7 exhibits the highest degree of group heterogeneity, with the difference between the maximum and minimum values exceeding 10 points. In this group, moreover, two subgroups seem to be discernible. The first is composed of Luxembourg and

Austria, which exhibit higher poverty levels for gross income, while the second consists of Czech Republic and Slovakia, with Slovenia transitioning from the latter to the former. Finally, G3 and G5 exhibit moderate levels of cohesion, with average poverty levels tending to increase for the first group and decrease for the second.

Regarding economic growth, the situation changes considerably, and all groups display a significant degree of cohesion. This cohesion is particularly strong for clusters G1, G2, G4, and G7, and somewhat less pronounced for G3, G5, and G6, especially after the Great Recession for the latter two. Overall, all groups experience a decline in economic growth following the 2008 crisis. Additionally, in the case of G4 and G5, they experience another decline in economic growth around 2012, related to the Sovereign Debt Crisis.

Figure 4.2 Group cohesion over the 2003-2019 period.





Source: Own elaboration from EUSILC data

4. Results

This section is aimed at illustrating the main findings obtained through the empirical procedure mentioned above. As one would expect, various channels are likely to exert a significant influence on the trajectory of the relationship between social and distributional variables and economic growth. Understanding the resulting trajectory is therefore crucial for shaping an effective policy mix and understanding the interactions between social policies and growth variable.

First of all, in Table 4.1 we analyse the possible variability in the association between every pair of variables of our model by means of correlation matrix. Thus, we need to address these values for the different groups of public systems to first capture the interactions between social and economic policies in the EU context, attending to the idiosyncrasies of each type of public welfare system. We propose a degree scale to obtain a better interpretation of these correlations in absolute terms. The initial interval covers values between 0 and 0.2, indicating a weak correlation. The subsequent interval denotes a moderate correlation, extending from 0.2 to 0.5. A strong correlation falls within the range of 0.5 to 0.8, whereas values exceeding 0.8 indicate a very strong correlation. It's worth noting that despite a low correlation between variables, a causal relationship may still exist.

At first glance, we can observe a high degree of heterogeneity both in terms of the direction of the relationships and their intensity. From the perspective of the different pairs of relationships,

we find that in most cases, economic growth and poverty exhibit a positive association, which indicates that both variables comove in the same direction. At the same time, we find mixed evidence regarding the relationship between inequality and economic growth, as well as between the two distributive variables themselves. In both cases, we find that for two of the country clusters, the variables move in opposite directions. For the relationship between inequality and economic growth these groups are the one formed by France, Malta and Cyprus -G6- on the one hand and by Austria, Luxembourg, Chez Republic, Slovakia and Slovenia -G7- on the other. Regarding the opposite association between inequality and poverty, the clusters are formed by Finland and Sweeden -G1- and by Hungary and Romania -G3-.

With respect to the intensity of relationships, we also observed a great deal of variation both between groups and between relationships. Thus, the association between growth and income inequality is moderate for G2 and strong for G3, consisting of Bulgaria, Estonia, Latvia and Lithuania and Hungary and Romania, respectively. In the rest of clusters of welfare state, the association seems somewhat weak. For the case of the relationship between poverty and economic growth, we find three cluster that also shows a weak association -G1, G3 y G6-: three with a moderate association -G2, G5 and 7- and just one with a strong association, which is G4. Finally, focusing on the association between the two distributive variables, G1, G2, and G6 show a weak association, G3 and G4 shows a moderate whereas G5 and G7 shows a strong association.

Table 4.1 Cross-correlation among income inequality, monetary poverty and economic growth

	G1	**G2**	**G3**	**G4**	**G5**	**G6**	**G7**	**ALL**
G⇔I	0.19	0.45	0.53	0.07	0.10	-0.19	-0.06	0.19
G⇔P	0.00	0.41	0.20	0.55	-0.44	0.18	0.32	0.18
I⇔P	-0.03	0.04	-0.35	0.46	0.60	0.01	0.59	0.26

Source: Own elaboration. (I) income inequality, (P) monetary poverty and (G) economic growth

Once we have checked the strength of the possible relations among our set of variables, we conduct the iterative process of the PC algorithm, in which all possible links among the variables selected are examined. In this sense, as we mentioned before, we have a set of three endogenous variable -income inequality, monetary poverty and economic growth- which can be linked by two possible nodes, iterating to two levels in which the remaining endogenous variable is incorporated in the last level. Thus, our approach begins with a bivariate analysis of all the possible connections (level 1). In this level, any causal linkage which is not significant is excluded from the following level. Indeed, in level 2, those causal relationships which have survived,- those that are significant in level 1-, are tested by adding the rest of the variables as a control. As an illustrative example, in order to be able to claim that economic growth has a *significant causal effect* on inequality -G⇒I- we have to assess significance of the relationship between both variables alone but also controlling by poverty. That is $G \Rightarrow I|_P$. Then, the results obtained by using the PC algorithm allow

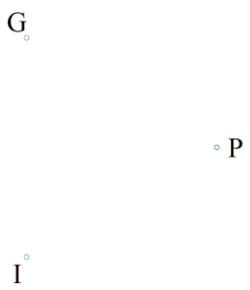
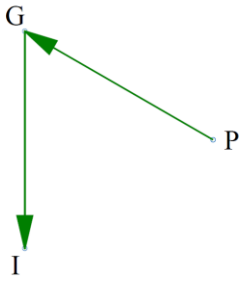
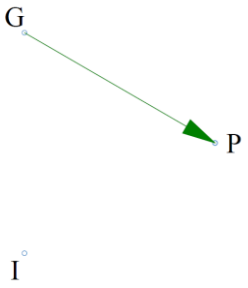
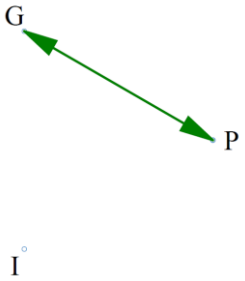
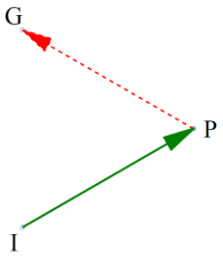
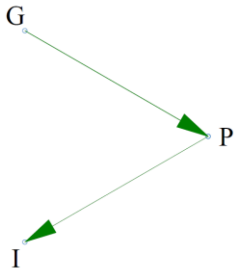
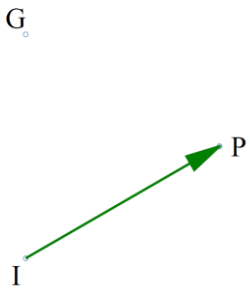
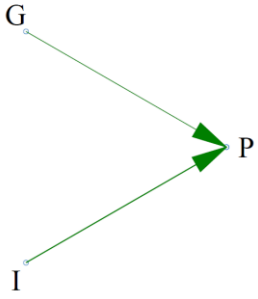
us to synthesise the significant surviving linkages, whereas the dominant correlation estimates between variables tell us about the direction and intensity of the relation.

These results have been presented along the lines of the causal maps literature in Figure 4.3, where it can be observed what was previously anticipated, it can be found a great degree of heterogeneity in the groups analysed. However, although it seems clear that there is no common pattern among the groups studied, some regularities do appear to recur with a certain frequency. Hence, we find that the relationship between economic growth and poverty is significant in 5 of the 7-welfare state cluster. In particular, we find that economic growth precedes and causes poverty in three of these cases -G2, G4 and G6. Likewise, although to a lesser extent, we also find that the relationship between inequality and poverty is significant in 3 of the 7 clusters. Finally, one of the most surprising findings of our study is that the relationship between economic growth and income inequality is direct in only one of the groups, whereas in the remaining groups, either no relationship exists or, if there is one, it is mediated through poverty.

Focusing now on the dynamics of the groups themselves, we can observe the following. In G1, the cluster formed by Nordic countries, no causal relationship between the three endogenous variables can be found, which could be indicative further research is necessary to identify other potential factors that may be influencing the relationship The G2 -formed by eastern European countries- is characterised by a dynamic leaded by the poverty, which positively cause economic growth, which, as a result, has a positive impact on income inequality. In G3 -which is formed by former communist countries- and G4 -formed by part of the Mediterranean countries- we find a very similar dynamic, where economic growth positively causes monetary poverty, although in the case of Mediterranean countries, this relationship it also found the other way round, with poverty also causing economic growth and turning into a bidirectional causal relationship. These results can be interpreted in the lines of *pro-rich*[43] growth literature, in the sense that economic growth does not benefit society as a whole equally, but is instead concentrated among the wealthiest households, thereby leading to an increase in poverty. G5 -integrated by the other Mediterranean countries and Poland- present a dynamic which is led by income inequality, which positively causes poverty. Poverty, in turn, has a negative effect on economic growth. Almost the opposite situation is found in group 6 -formed by Cyprus, Malta and France. In this case, economic growth leads the dynamic, positively affecting poverty, which in turn causes inequality. Finally, in G7- formed by Central European – we only find a positive causal relationship from inequality to poverty, and no interaction with economic growth.

[43] In the specialized literature, there are different definitions of pro-rich growth. In this article, the term is used to describe a situation in which those with higher incomes benefit to a greater extent from economic growth.

Figure 4.3 PC algorithm. Final map

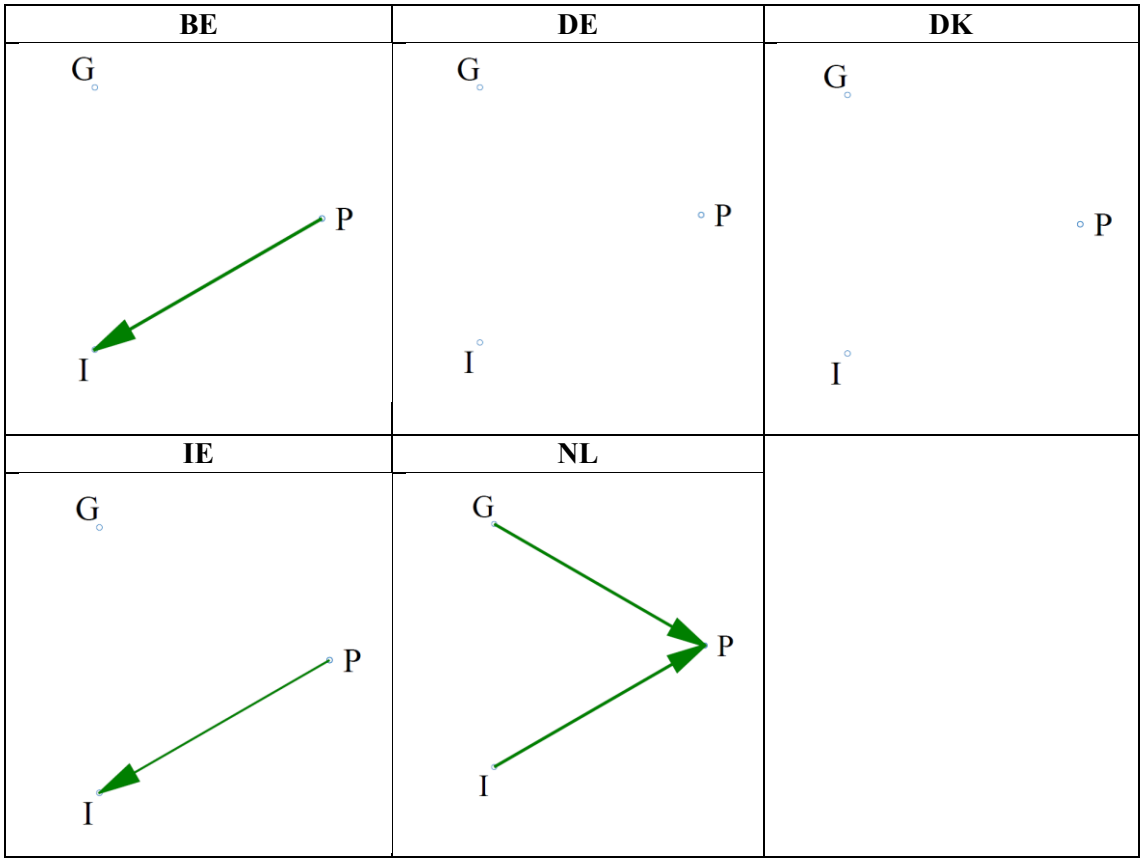
GR 1: FI and SE	*GR 2: BG, EE, LT and LV*
	
GR 3: HU and RO	*GR 4: ES and IT*
	
GR 5: EL, PL and PT	*GR 6: CY, MT and FR*
	
GR 7: AT, CZ, LU, SI and SK	*Total sample countries*
	

Source: Own elaboration with Causality Map Toolbox.
Notes: (1) Results obtained from Granger's causality test at 10% of significance level, for the period 2003-2023. Solid (Dashed) line indicates that the crossed correlation between each pair of nodes is positive (negative). Finally, the wider the line, the higher this value.

Next, in Figure 4.3 we present a complementary look to our results which consist in analysing the unclustered country specific causal maps. subsets. This could be informative in terms of identifying specific profiles. At first glance, some of the results observed for the different

groupings of countries can be confirmed. Once again, we find significant heterogeneity regarding the significance of the relationships, depending on the country analysed. Thus, we observe that in the case of Germany and Denmark, none of the relationships are significant. Similarly, for Belgium and Ireland, we can see that the only relationship that persists is the positive effect from poverty to inequality. Finally, in the case of Netherlands, we observe a dual positive causal relationship originating from inequality and economic growth, both of which affect poverty. However, some of the regularities that we found for the aggregate analysis can also be found. Yet again, we find a significant relationship between poverty and inequality in 3 of the 5 cases studied. Likewise, in only one of the seven cases studied was a direct relationship between economic growth and income inequality found to survive.

Figure 4.4 Multivariate causality test analysis, estimates from baseline model: unclustered cross-country comparison.

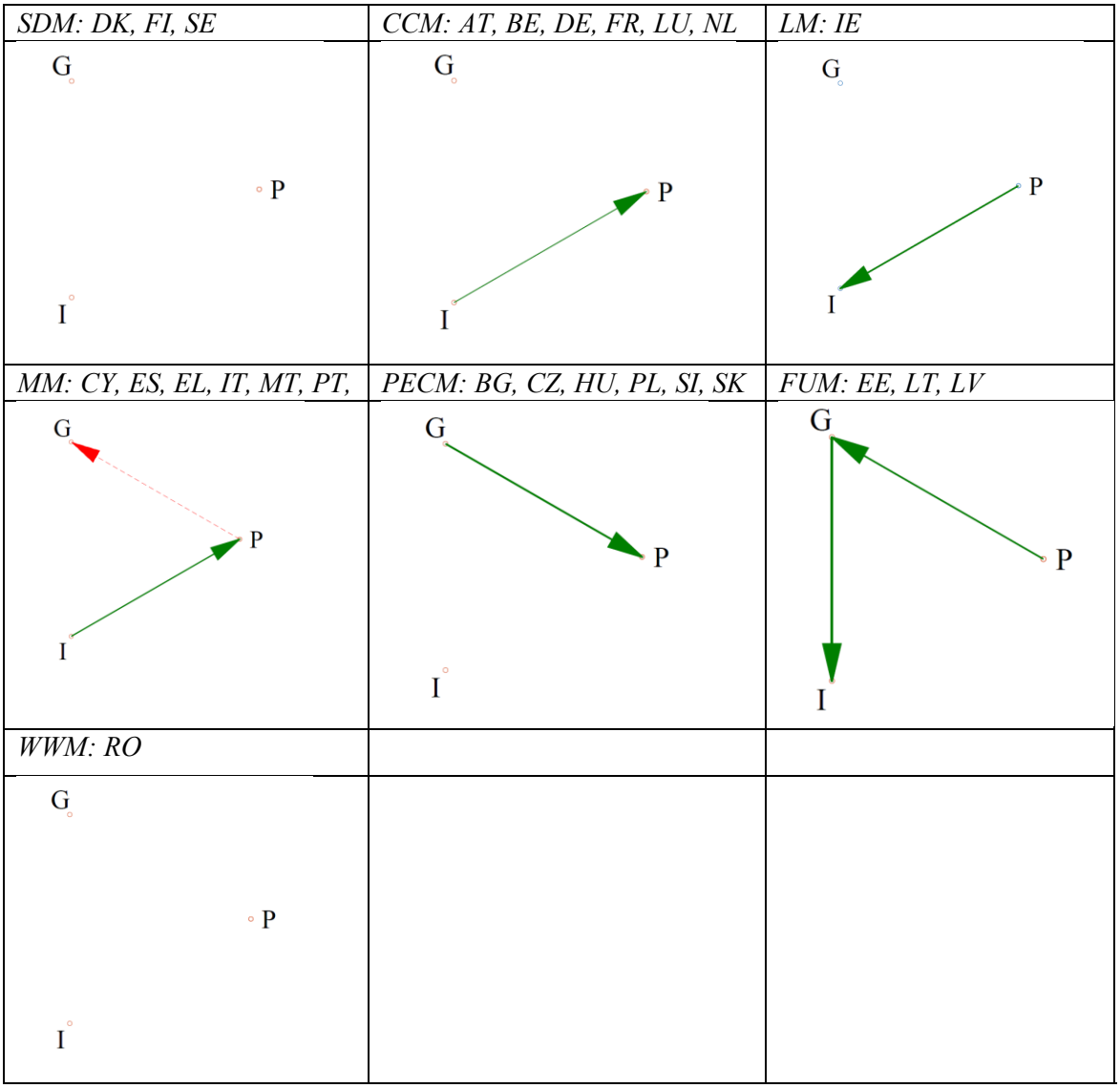


Source: Own elaboration with Causality Map Toolbox.
Notes: (1) Results obtained from Granger's causality test at 10% of significance level, for the period 2003-2023. Solid (Dashed) line indicates that the crossed correlation between each pair of nodes is positive (negative). Finally, the wider the line, the higher this value.

Finally, as a robustness check, in Figure 4.5 we have repeated the analysis using the traditional classification proposed in Esping-Andersen (1990) and subsequent extensions as an exogenous criterion for grouping countries. It can be observed that in countries that belong to the Social Democratic Model -SDM-, the Liberal Model -LM- and the Weak Welfare State Model- WWM-

no relationship between the distributional phenomena and economic growth can be found. In the case the Corporatist Centro-European Model, we find a positive relationship from income inequality to poverty. In the Mediterranean Model it can be observed the income inequality leads the dynamics between the variables, having a positive effect on monetary poverty. The poverty impacts negatively on economic growth. Post-Communist European model -PECM countries show a positive effect from economic growth to poverty. Finally, FUM-Former URSS model-countries present a dynamic lead by monetary poverty, which positively cause economic growth, which is then followed by a positive effect on income inequality.

Figure 4.5 PC algorithm. Final map



Source: Own elaboration

Notes: (1) Results obtained from Granger's causality test at 10% of significance level, for the period 2003-2023. Solid (Dashed) line indicates that the crossed correlation between each pair of nodes is positive (negative). Finally, the wider the line, the higher this value.

5. Concluding remarks

The debate on the effects of different distributive variables - inequality and poverty - on economic growth has been one of the most fruitful since the publication of Kuznets' (1955). seminal work While there are reasons that argue that the effect of an increase in inequality can have positive effects, implying an incentive to economic growth, we also find positions that argue just the opposite. From the academic point of view, there is no greater consensus. Thus, we find empirical studies that find both negative and positive relationships. Among the various reasons that have been pointed out as possibly responsible for this multiplicity of results emerges the need to carry out studies that take into account the similarity of the countries and classify them according to the homogeneity of their institutional systems (Borge and Rattsø, 2004).

In this regard, in this paper we have analysed the relationship between income inequality, monetary poverty and economic growth in different cluster of countries grouped by kinds of welfare states with the aim of searching for common patterns related to the public systems. To do so, we have used a novel classification proposed in the Chapter 3 of this thesis, which classify the countries according to the distribution of its resources. Then, a Granger causal analysis for the period 2003-2019 is performed for each cluster. The econometric approach relies on the work of Dumitrescu and Hurlin (2012) and Emirmahmutoglu and Kose (2011) who proposed a strategy to compute panel data estimators based on the individual information of the cross-sectional units -countries- conforming each subgroup.

Our results show that there is a high degree of heterogeneity in terms of relationships depending on the cluster of countries we examine. Thus, while for the first group of countries - formed by Finland and Sweeden - there is no effect between the three variables, we find very different dynamics for the rest of the groups. While for G2 -formed by Bulgaria, Estonia, Latvia and Lithuania- we find that poverty seems to positively affect economic growth and this, in turn, inequality. For G3 -Hungary and Romania- we observe that the only significant relationship is the one that originates in economic growth and positively *causes* poverty. This same relationship, but with a bidirectional character, is the only one found significative in G4 - Spain and Italy. The group formed by Greece, Poland and Portugal presents a dynamic led by inequality, which positively affects poverty. Poverty, in turn, has negative effects on economic growth. In the G6 - formed by Cyprus, Malta and France - economic growth has a positive effect on poverty and poverty has a positive effect on inequality. Finally, in the G7 - Austria, Czech Republic, Luxembourg, Slovenia and Slovakia - inequality has a positive effect on poverty.

Despite this, it is also possible to find certain features or regularities that are repeated with a certain frequency. Perhaps most striking is that only in one of the groups is there a direct relationship between inequality and economic growth. However, this does not imply that both

variables are not related, but rather that in other cases this relationship is mediated through poverty. This would indicate the need to include both variables simultaneously in order to correctly capture the underlying dynamics between these phenomena. In contrast, the direct relationship between economic growth and poverty is significant in 5 of the 7 groups analysed. In 3 of the 5 groups analysed, growth not only does not reduce poverty, but increases it. In these groups of economies, pro-rich economic growth seems to be occurring. Likewise, in 2 of the 5, poverty precedes economic growth, which would be in line with the efficiency thesis.

The present study is not without limitations. The main findings rely only one measure of inequality, poverty and economic growth, so as a further research line it could be interesting to test other indicators. At the same time, it may be interesting to go beyond the object of analysis of the paper and exploit the potential of microdata to analyse whether these relationships may change depending on different socioeconomic status. Finally, it might be of interest to address for potential non linearities between variables.

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Conclusiones

Esta tesis doctoral se ha desarrollado con el objetivo de analizar las relaciones de causalidad que existen entre la desigualdad de ingreso, la pobreza monetaria y el crecimiento económico para 30 de los estados europeos durante el periodo 2003-2019. Este tema ha sido ampliamente estudiado en la literatura especializada y se han producido numerosos trabajos empíricos, especialmente a partir de los años noventa. Asimismo, también ha formado parte del debate social tras la crisis económica derivada de la Gran Recesión. No obstante, a pesar del volumen de análisis producidos no existe un consenso claro acerca de la naturaleza de la relación. Muchos de estos trabajos presentan rasgos comunes que pueden influir en la falta de consenso. Es por ello que parte de las decisiones adoptadas en esta tesis tienen el objetivo de complementar las aproximaciones y enfoques que han sido habituales en la literatura.

Para ello, en el primer capítulo hemos hecho una contribución metodológica que combina los avances producidos en el cómputo de indicadores de causalidad sintéticos en modelos VAR para datos de panel con los producidos en el campo de modelos gráficos y mapas causales (Directed Acyclic graph, DAGs). Esta contribución permite incrementar a un bajo coste computacional el número de variables endógenas incluidas en el análisis económico, habitualmente limitada a dos o, en ocasione menos habituales, tres. Esto permite y facilita poner en diálogo distintas ramas de la literatura especializada y combinarlas en un marco de información más complejo, lo que a su vez supone la posibilidad de contrastar si la confirmación de distintas hipótesis derivada a partir de resultados obtenidos a partir de modelos reducidos continúa manteniéndose en modelos extendidos.

Para ilustrar las ventajas que este enfoque metodológico hemos llevado a cabo dos ilustraciones complementarias sobre la dinámica de la Curva de Phillips, por un lado, y el nexo entre los precios, salarios y consumo privado, por otro, para los países miembros de la UEM. Aunque ambos análisis se alejan del tema de interés abordado en esta tesis, suponen una aportación novedosa a toda una rama de la literatura académica sobre la que ha resurgido el interés a partir de la escalada de precios producida tras la crisis del COVID-19, el conflicto bélico en Ucrania y el aumento de las tensiones geopolíticas. De esta forma, la primera de las ilustraciones abarca el periodo 2003-2019 y se ha centrado en estudiar la dinámica entre la inflación y el desempleo, con la novedad de que pueden llegar a incluirse simultáneamente en el análisis un mayor número de variables endógenas– en nuestro caso PIB, consumo privado, salarios, coste de endeudamiento que soportan las familias y gasto público total- que pueden resultar relevantes a la hora de determinar la dinámica subyacente. Así, es posible estudiar la validez de la relación principal -desempleo e inflación- a medida que se van introduciendo en el análisis el resto de potenciales catalizadores. En un primer momento, cuando limitamos nuestro análisis a modelos bivariantes o trivariantes -en los que se incluyen respectivamente inflación y desempleo, además de otras de

las variables incluidas en el análisis- los resultados parecen confirmar la hipótesis de la Curva de Phillips, ya que prácticamente en todos hallamos un relación significativa e inversa entre ambas variables. Sin embargo, a medida que analizamos modelos más complejos, estos resultados dejan de confirmarse. En la etapa final de nuestro análisis planteamos un modelo complejo en el que todas las variables de interés se están incluidas de forma simultánea como variables endógenas. Los resultados obtenidos confirman la prevalencia de resultados no significativos respecto a la relación entre el desempleo y la inflación para el conjunto del panel y, además, para un subconjunto significativo de países (centroeuropeos y periféricos).

También identificamos las variables que dirigen la dinámica subyacente para todo el panel. Es decir, aquellas que suceden primero en la secuencia causal y no son causadas por ninguna del resto de variables incluidas en el modelo. Estas son el PIB, inflación y tasa de desempleo para el conjunto de los países.

A nivel nacional, sólo cuatro países (Grecia, Finlandia, Italia y Luxemburgo) mantienen parcialmente una relación significativa -inversa- entre la inflación y la tasa de desempleo, pero no bidireccional. Por último, también obtenemos un alto grado de heterogeneidad entre países en términos de la dinámica subyacente, lo que indica que pueden ser necesarias políticas específicas de cada país.

La segunda de nuestras aplicaciones explota desde una perspectiva diferente las ventajas que ofrece el enfoque propuesto. Para ello, analizamos la dinámica que se produce entre los precios, el consumo privado y los salarios en el periodo 1999-2019, atendiendo a la variación de resultados en términos de las unidades -países- incluidas en nuestra muestra. La relación entre estas variables se ha estudiado previamente de forma amplia en la teoría económica, proponiendo distintas hipótesis que predicen que las relaciones pueden operar tanto en un sentido como en el contrario. En este contexto, nuestros resultados ayudan tanto a confirmar como a desmentir para el periodo y muestra analizados algunas de las hipótesis propuestas. Para el conjunto del panel obtenemos un nexo causal significativo y positivo entre precios y salarios y entre precios y consumo, lo que parece confirman tanto la conocida como hipótesis de la indexación como la hipótesis de las expectativas. Asimismo, no encontramos evidencia de una relación causal directa entre el consumo privado y los salarios, sino que esta se vehicula a través de un vínculo indirecto entre otras variables.

Sin embargo, cuando atendemos a de cada país de forma individual, observamos que se produce un alto grado de heterogeneidad en los resultados. Esto nos permite examinar qué casos concretos participan de los hallazgos comunes encontrados en el conjunto y cuáles se comportan según un patrón más específico. Así, encontramos para todos los países una relación causal positiva de los precios a los salarios, excepto en el caso de los Países Bajos. Por el contrario, la relación opuesta,

de los salarios a los precios, no resulta significativa en prácticamente ningún país (con la excepción de Francia). En cuanto al efecto de los precios en el consumo privado, esta parece una relación muy robusta, ya que es significativa en el sistema para todos los países. Por último, si nos centramos en el vínculo causal entre salarios y consumo, observamos que España es la única economía para la que hallamos una relación significativa.

En el segundo capítulo, hemos aplicado esta propuesta metodológica al tema principal de análisis de la tesis: la dinámica causal que se produce entre la desigualdad de ingresos, la pobreza monetaria y el crecimiento económico para un conjunto de 30 economía europeas durante el periodo 2003-2019. Esto nos permite superar alguna de las limitaciones habitualmente presentes en la literatura empírica y contribuir al estudio sobre la naturaleza de la relación entre tales fenómenos. De esta forma, analizamos de forma simultánea la dinámica causal que se produce entre los tres fenómenos, sin tratar de establecer el orden de la secuencia a priori sino basándonos en un enfoque algo más neutral y basado en los datos (*data driven approach)*. Asimismo, las economías elegidas se circunscriben al ámbito europeo, lo que también resulta una novedad, ya que habitualmente este tipo de estudios se ha llevado a cabo, sobre todo, para economías en desarrollo. Por último, los indicadores utilizados están calculados a partir de los microdatos de la Encuesta europea sobre los ingresos y condiciones de vida (EUSILC por sus siglas en inglés), recogidos a nivel armonizado por Eurostat. Esta dos últimas cuestiones nos garantizan un mayor grado de comparabilidad entre los países incluidas en el análisis, tanto por las características estructurales de las economías como por la homogenización en el tratamiento de los datos, lo que puede ser fundamental a la hora de analizar la existencia de patrones comunes.

Los resultados obtenidos muestran que la dinámica viene liderada por el crecimiento económico, siendo esta variable la causa inicial entre los tres fenómenos. Sin embargo, a pesar de lo que cabría esperar por los resultados de la literatura previa, el crecimiento económico no parece tener un efecto reductor en la pobreza sino al contrario, ya que la relación causal obtenida es significativa y positiva. Asimismo, hallamos que entre la pobreza y la desigualdad también existe un vínculo causal positivo y bidireccional, lo que estaría indicado la existencia de una relación recíproca entre ambos fenómenos. Esto nos permite desentrañar la dinámica de la siguiente manera: en primer lugar, el crecimiento económico actúa como catalizador, provocando la pobreza. Al mismo tiempo, tanto la pobreza como la desigualdad económica comparten una tendencia común que da lugar a un proceso de círculo vicioso entre ambas.

Estos resultados apoyan la hipótesis desarrollada en literatura del crecimiento a favor de los ricos *(pro-rich growth)*, según la cual el crecimiento económico no se distribuye equitativamente entre la población debido a la prevalencia de ciertos niveles de desigualdad, lo termina traduciéndose

en un aumento de la pobreza. Además, desde perspectivas diferentes, estos resultados se alinean con los últimos trabajo sobre la naturaleza de la relación entre los tres fenómenos en Europa[44].

De estos resultados extraemos dos conclusiones principales: en primer lugar, a lo largo del periodo estudiado, el crecimiento económico no ha resultado una herramienta eficaz para reducir la desigualdad y la pobreza en el conjunto de las economías analizadas, lo que se opone a la hipótesis de que el crecimiento económico sigue un flujo vertical desde los ricos hacia los pobres. En segundo, la doble causalidad encontrada entre las variables distributivas puede estar produciendo un proceso de refuerzo y dificultando la reversión del empeoramiento general observado en la pobreza y la desigualdad en parte del periodo analizado. Sin embargo, de nuevo es posible observar un alto grado de heterogeneidad entre países.

El capítulo tercero y cuarto han tenido el objetivo de abordar la heterogeneidad hallada en los resultados del capítulo dos. Para ello, el objetivo del capítulo tres cosiste en proponer una nueva taxonomía de estados de bienestar europeos, entendidos estos como sistemas públicos de prestaciones e impuestos. Como se mencionó en la introducción de la tesis, este objetivo también se aborda desde una perspectiva *data driven.* En particular, se han implementado técnicas de análisis de clúster basadas en procesos de aprendizaje automático no supervisado. Los indicadores incluidos en el análisis están calculados a partir de los microdatos producidos a través de EUROMOD y reflejan cómo los Estados del bienestar distribuyen sus prestaciones e impuestos entre la población, así como la forma en la que conforman la composición de estos a nivel agregado. Asimismo, como novedad en el enfoque adoptado, introducimos la perspectiva temporal, que suele estar ausente en este tipo de análisis debido a la naturaleza estática de la mayoría de las técnicas de agrupación. Para ello, realizamos el análisis de forma independiente para cada año del periodo 2008-2019, así como para una serie de transformaciones del mismo (medias móviles y distinción de la fase del ciclo) con el objetivo de evitar el sesgo introducido por años concretos en la clasificación obtenida.

Nuestros resultados apuntan a la existencia de 7 grupos diferentes en la UE, la mayoría de ellos congruentes con las clasificaciones habituales, como es el caso de los países nórdicos o de Europa del Este. Sin embargo, también hallamos que se ha producido una fragmentación de otros grupos tradicionales. Por ejemplo, el conocido como modelo mediterráneo parece haberse escindido en dos, con España e Italia por una lado y Grecia y Portugal -además de Polonia- por otro. Por el contrario, algunos de los grupos habituales parecen haberse fusionado, conformando un único grupo. Es el caso de Austria y Luxemburgo, que se han unido a Eslovaquia, Eslovenia y la República Checa.

[44] Ver el Capítulo 2 para más detalles.

Por último, encontramos algunos países que no se configuran en ningún grupo, sino que oscilan entre varios de ellos de forma independiente, como es el caso de Bélgica o Países Bajos. Esto iría en la línea de las afirmaciones que concluyen que «en el mundo real» la mayoría de los países se situarían entre los modelos ideales, siendo casos híbridos.

Finalmente, en el capítulo 4 hemos abordado de nuevo el objetivo de analizar la dinámica causal subyacente entre la desigualdad, la pobreza y el crecimiento económico, pero subdividiendo y clasificando los países de la muestra según las agrupaciones obtenidas en el capítulo 3. De esta forma, es posible analizar si las similitudes en el tipo de estado de bienestar desempeñan algún papel en la mediación de esas relaciones. Nuestros resultados muestran, de nuevo, que existe un alto grado de heterogeneidad según el grupo de países que examinemos. Para el primer grupo de países -formado por Finlandia y Suecia- no hallamos ninguna relación significativa entre las tres variables, lo que podría ser indicativo de que para estas economías la evolución de los fenómenos está asociada a causas estructurales y no tanto de coyuntura económica.

Para el resto de grupos, encontramos dinámicas muy diferentes. Mientras que para el grupo dos -formado por Bulgaria, Estonia, Letonia y Lituania- encontramos que la pobreza parece afectar positivamente al crecimiento económico y éste, a su vez, produce un incremento de la desigualdad, para el grupo tres -Hungría y Rumanía- observamos que la única relación significativa es la que se origina en el crecimiento económico y provoca positivamente la pobreza. Esta misma relación, pero con carácter bidireccional, es la única que resulta significativa en el grupo cuatro – formado por España e Italia-. El grupo formado por Grecia, Polonia y Portugal presenta una dinámica liderada por la desigualdad, que causa positivamente a la pobreza. La pobreza, a su vez, tiene efectos negativos sobre el crecimiento económico. En el grupo seis -formado por Chipre, Malta y Francia- el crecimiento económico tiene un efecto positivo sobre la pobreza y la pobreza tiene un efecto positivo sobre la desigualdad. Por último, en el grupo siete - Austria, República Checa, Luxemburgo, Eslovenia y Eslovaquia - la desigualdad tiene un efecto positivo sobre la pobreza.

A pesar de la variedad de resultados obtenidos, también es posible encontrar ciertos patrones comunes. Lo más llamativo es que sólo en uno de los grupos encontramos una relación directa entre desigualdad y crecimiento económico, a pesar de que ha sido una de las relaciones que más interés ha acaparado en la literatura relacionada. Sin embargo, esto no implica que ambas variables no estén relacionadas, sino que en otros casos esta relación está mediada a través de la pobreza, lo que refuerza la necesidad de incluir ambas variables simultáneamente para captar correctamente la dinámica subyacente entre estos fenómenos.

Conclusions

This doctoral dissertation has been developed with the aim of analysing the causal relationships between income inequality, monetary poverty, and economic growth for 30 European states during the period 2003-2019. This topic has been widely studied in the specialized literature, and numerous empirical studies have been produced, especially since the 1990s. Likewise, it has also been part of the social debate following the economic crisis stemming from the Great Recession. However, despite the volume of analyses produced, there is no clear consensus on the nature of the relationship. Many of these studies share common characteristics that may contribute to the lack of consensus. For this reason, some of the decisions adopted in this thesis aim to complement the approaches and methodologies that have been common in the literature.

To this end, in the first chapter, we have made a methodological contribution that combines advances in the computation of synthetic causality indicators in VAR models for panel data with those developed in the field of graphical models and causal maps (Directed Acyclic Graphs, DAGs). This contribution allows for an increase in the number of endogenous variables included in economic analysis at a low computational cost, typically limited to two or, less commonly, three. This enables and facilitates the dialogue between different branches of the specialized literature and to combine them in a more complex information framework, which in turn implies the possibility of contrasting whether the confirmation of different hypotheses derived from results obtained from reduced models continues to be maintained in extended models.

To illustrate the advantages of this methodological approach, we have conducted two complementary applications: one on the dynamics of the Phillips Curve and another on the nexus between prices, wages, and private consumption for the member countries of the EMU. Although both analyses diverge from the main topic addressed in this thesis, they represent a novel contribution to an entire branch of academic literature that has seen renewed interest following the price surge triggered by the COVID-19 crisis, the war in Ukraine, and the rise in geopolitical tensions. The first of the illustrations covers the period 2003-2019 and has focused on studying the dynamics between inflation and unemployment, with the novelty that a larger number of endogenous variables are included simultaneously in the analysis - in our case GDP, private consumption, wages, household borrowing costs and total public expenditure -, which may be relevant in determining the underlying dynamics. Thus, it is possible to study the validity of the main relationship -unemployment and inflation- as the rest of the potential catalysts are sequentially incorporated into the analysis. Initially, when limiting our analysis to bivariate or trivariate models -including inflation and unemployment, along with one of the additional variables- our findings appear to confirm the Phillips Curve hypothesis, since in practically all of the reduced models we find a significant and inverse relationship between both variables. However, as we move to more complex models, these results are no longer confirmed. In the final

stage of our analysis, we consider a comprehensive model in which all variables of interest are simultaneously included as endogenous variables. The results obtained confirm the prevalence of non-significant results regarding the relationship between unemployment and inflation for the entire panel and, moreover, for a significant subset of countries (both Central European and peripheral).

We also identify the variables that direct the underlying dynamics for the whole panel. That is, those that occur first in the causal sequence and are not caused by any of the other variables included in the model. These are GDP, inflation and unemployment rate for the set of countries.

At the country level, only four countries (Greece, Finland, Italy and Luxembourg) partially maintain a significant -inverse- relationship between inflation and the unemployment rate, but not bidirectional. Finally, we also observe a high degree of heterogeneity across countries in terms of the underlying dynamics, indicating that country-specific policies may be necessary.

The second of our applications exploits the advantages offered by the proposed approach from a different perspective. In this case, we analyse the dynamics between prices, private consumption, and wages during the period 1999-2019, attending to the variation of results in terms of the units -countries- included in our sample. The relationship between these variables has previously been studied extensively in economic theory, proposing different hypotheses predicting that relationships can operate both in one direction and in the opposite. In this context, our results contribute to both confirming and rejecting hypotheses for the analysed period and sample some of the proposed. For the panel as a whole, we obtain a significant and positive causal link between prices and wages and between prices and consumption, which seems to confirm both the indexation hypothesis and the expectations hypothesis. Additionally, we do not find evidence of a direct causal relationship between private consumption and wages; instead, this relationship is mediated through an indirect link involving other variables.

However, when we examine at each country individually, we observe that there is a high degree of heterogeneity in the results. This allows us to examine which specific cases participate in the common findings found in the aggregate and which ones behave according to a more specific pattern. Thus, we find a positive causal relationship from prices to wages in all countries except for the Netherlands. In contrast, the opposite relationship, from wages to prices, is not significant in practically any country (with the exception of France). As for the effect of prices on private consumption, this appears to be a very robust relationship, as it is significant in the system for all countries. Finally, if we focus on the causal link between wages and consumption, Spain is the only economy for which we find a significant relationship.

In the second chapter, we have applied this methodological proposal to the main subject of analysis of the thesis: the causal dynamics between income inequality, monetary poverty, and

economic growth for a group of 30 European economies during the period 2003-2019. This allows us to overcome some of the limitations usually present in the empirical literature and to contribute to the study of the nature of the relationship between these phenomena. In this way, we simultaneously analyse the causal dynamics between the three phenomena, without attempting to establish the sequence order a priori, but rather relying on a more neutral, data-driven approach. Furthermore, the selected economies are limited to the European context, which is also novel, since this type of study has usually been typically conducted primarily for developing economies. Lastly, the indicators used are calculated on the basis of microdata from the European Survey of Income and Living Conditions (EUSILC), collected at a harmonized level by Eurostat. These last two aspects guarantee a higher degree of comparability among the countries included in the analysis, both because of the structural characteristics of the economies and because of the homogenization in the treatment of the data, which can be fundamental when analysing the existence of common patterns.

The results obtained show that the dynamics are led by economic growth, this variable being the initial cause among the three phenomena. However, despite what might be expected from the results of previous literature, economic growth does not appear to have a poverty-reducing effect, but rather the opposite, since the causal relationship obtained is significant and also positive. Additionally, we find that there is also a positive and bidirectional causal link between poverty and inequality, which would indicate the existence of a reciprocal relationship between both phenomena. This allows us to unravel the dynamics as follows: first, economic growth acts as a catalyst, leading to an increase in poverty. At the same time, both poverty and economic inequality share a common trend, resulting in a vicious cycle between them.

These results are in line with the hypothesis developed in the literature of *pro-rich* growth, which suggests that economic growth is not equally distributed across the population due to the persistence of certain levels of inequality, ultimately leading to an increase in poverty. Furthermore, from different perspectives, these findings align with the works of last years about the nature of the relationships between these phenomena[45].

We draw two main conclusions from these results: first, throughout the period studied, economic growth has not been an effective tool for reducing inequality and poverty in the economies analysed, which contradicts the hypothesis that economic growth follows a vertical flow from the rich to the poor (trickle-down hypothesis). Second, the bidirectional causality found between the distributive variables may be creating a reinforcing process, making it more difficult to reverse

[45] See Chapter 2 for more details.

the general worsening observed in poverty and inequality during part of the analysed period. However, once again, a high degree of heterogeneity among countries can be observed.

The third and fourth chapters aimed to address the heterogeneity found in the results of the second chapter. To this end, the objective of the third chapter is to propose a new taxonomy of European welfare states, understood as public tax-benefits systems. As mentioned in the introduction of the thesis, this objective is also approached from a data-driven perspective. In particular, cluster analysis techniques based on unsupervised machine learning processes have been implemented. The indicators included in the analysis are calculated from the microdata produced through EUROMOD and reflect how welfare states distribute their benefits and taxes among the population, as well as how these are composed at an aggregate level. Also, as a novelty in the approach adopted, we introduce the time perspective, which is often absent in this type of analysis due to the static nature of most clustering techniques. To achieve this, we conducted the analysis independently for each year within the 2008-2019 period, as well as for a series of transformations (moving averages and distinctions based on the phase of the cycle) with the aim of avoiding the bias introduced by specific years in the classification obtained.

Our results indicate the existence of seven distinct groups within the EU, most of which align with traditional classifications, such as the Nordic countries or Eastern Europe. However, we also find that fragmentation has occurred in other traditional groups. For instance, the so-called Mediterranean model appears to have split into two, with Spain and Italy on one side and Greece and Portugal—along with Poland—on the other. Conversely, some of the typical groups seem to have merged into a single group. This is the case for Austria and Luxembourg -usually classified as Corporatist Centro-European Model- , which have joined Slovakia, Slovenia, and the Czech Republic.

Finally, we find some countries that do not fit into any specific group but instead oscillate independently between several of them, as is the case as Belgium or the Netherlands. This would be in line with the statements that "in the real world," most countries would fall between ideal welfare model types, representing hybrid cases.

Finally, in chapter 4 we have again addressed the objective of analysing the underlying causal dynamics between inequality, poverty and economic growth, but subdividing and classifying the countries in the sample according to the groupings obtained in chapter 3. Our results show, again, that there is a high degree of heterogeneity according to the group of countries we examine. For the first group of countries - Finland and Sweden - we do not find any significant relationship between the three variables, which could be indicative that for these economies the evolution of the phenomena is associated with structural causes rather than short-term economic factors.

For the remaining groups, we found very different dynamics. For the second group—comprising Bulgaria, Estonia, Latvia, and Lithuania—we observed that poverty seems to have a positive effect on economic growth, which in turn leads to an increase in inequality. In the third group—Hungary and Romania— we observe that the only significant relationship is the one that originates in economic growth and positively causes poverty. This same relationship, but with a bidirectional effect, is the only significant one in the fourth group—formed by Spain and Italy. The group formed by Greece, Poland, and Portugal presents a dynamic led by inequality, which positively causes poverty. Poverty, in turn, has a negative effect on economic growth. In the sixth group—comprising Cyprus, Malta, and France—economic growth has a positive effect on poverty, and poverty has a positive effect on inequality. Finally, in the seventh group—Austria, the Czech Republic, Luxembourg, Slovenia, and Slovakia—inequality has a positive effect on poverty, causing an increase in the later.

Despite the variety of results obtained, it is also possible to find certain common patterns. The most striking is that only in one of the groups we find a direct relationship between inequality and economic growth, despite the fact that it has been one of the relationships that has attracted most interest in the related literature. However, this does not imply that both variables are unrelated, but rather that in other cases this relationship is mediated through poverty, which reinforces the need to include both variables simultaneously in order to correctly capture the underlying dynamics between these phenomena.