# Sustainable Growth, Competitiveness, Innovation, Tourism and Welfare – New Challenges for the World Economy

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**Transformation and Validity of Structural Uses**

**Transformación y vigencia de los usos estructurales**

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Abstract

This paper sets out the main changes in the notions of structure and the uses related, since the fall of classical structuralism. For this purpose, it has been followed the division by levels of analysis between ontology, analysis and structural model. As a result, a diversity of approaches has been revealed: from those who seek compatibility with the mainstream economy to those closer to a perception of the economy as a social science. In this way, it has been possible to show some ways of solving the limitations of classical structuralism on the perception of systems and the relationship with individual action. In spite of it, the long term and the way of working the relations with the socio-historical disciplines continues presenting itself controversial.

Keywords: Structure, Structural Analysis, Structural Uses

Resumen

El presente trabajo plantea cuales han sido los principales cambios en las nociones de estructura y los usos vinculados a ella, desde la caída del estructuralismo clásico. Con este fin, se ha seguido la división por niveles de análisis entre ontología, análisis y modelo estructural. Gracias a ello se han revelado una diversidad de enfoques de trabajo: desde aquellos que buscan una compatibilidad con la economía convencional a los que se encuentran más cercanos a una percepción de la economía como ciencia social. De esta forma, ha sido posible presentar algunas formas de superar las limitaciones del estructuralismo clásico sobre la percepción de los sistemas y la relación con la acción individual. Pese a ello, el largo plazo y la forma de trabajar las relaciones con las disciplinas sociohistóricas continúa presentándose como materia de controversia.

Palabras clave: estructura, análisis estructural, uso estructural

Clasificación JEL: A 12, B 41

Área temática de preferencia: nuevas metodologías en el estudio de la economía mundial

## 1. Introducción

Con el colapso de la corriente estructuralista clásica, sus propuestas en economía fueron puestas en cuestión y desplazadas de los centros de decisión. En ello confluyeron su incapacidad de respuesta ante los cambios en la economía mundial y las presiones tanto de la marea neoclásica como de la nueva política económica. De poco sirvió que más tarde se rescataran las críticas tempranas a las malas interpretaciones, ante la acumulación de errores y las deficiencias en la validación de las propuestas. Tampoco que se señalaran los excesos de las críticas y el desprecio a los estudios regionales y a sus resultados empíricos.

Desde entonces, la posición que guio las prácticas del análisis estructural fue la de mantener la utilidad del concepto de estructura y de los usos vinculados con ella (Berzosa: 1995). Pese a ello, el enfoque ha quedado en cuestión en cuanto a su capacidad para establecer conocimientos. En este contexto, el presente trabajo presenta una reflexión sobre esos conceptos de estructura y los principales problemas que presentan los usos vinculados a ella.

Con este fin, se ha asumido el camino que propuso Beiras (1987) al hablar de tres niveles del concepto de estructura: el del campo ontológico, el del análisis estructural y el del modelo estructural. Se trata de una estratificación común a la hora de delimitar la capacidad explicativa de un concepto teórico, que pregunta en primer lugar por la composición y el material de la estructura en la realidad. El segundo nivel se refiere a los aspectos fundamentales relacionados con la aparición de las estructuras, las propiedades y efectos que tiene o su reproducción. El tercer nivel atiende a cuestiones relacionadas con el cambio, la dinámica y la transformación.

La diferencia con respecto a la propuesta de Beiras se encuentra en el enfoque con que se abordan los distintos niveles de análisis. Su punto de vista, encuadrado dentro del marxismo, considera que solo es posible revelar las estructuras subyacentes a las relaciones que se dan en la realidad en el modelo estructural. Como consecuencia, desestima las nociones y análisis que no asuman la existencia de tal modelo. El problema se encuentra en la existencia o no de regularidades en el campo histórico, que refieren a los problemas de la teoría del cambio histórico o de leyes de transformación de la sociedad. Frente a este enfoque y con la voluntad de cambios en los términos del debate y nuevas salidas, se mantiene que las nociones de estructura que se manejan en la realidad tienen influencia sobre los métodos que se desarrollan a partir de ellas. La consistencia entre ellas es relevante a la hora de establecer el alcance de los conocimientos que se pueden alcanzar que tienen desde el punto de vista teórico

Con este fin, en el primer punto se han planteado las posibles diferencias entre los conceptos de estructura en la realidad, lo que ha conducido a una separación entre las que se han considerado definiciones compatibles con la economía convencional y las que no. A partir de esta diferencia ontológica, se han tomado en consideración tres grupos distintos de propuestas sobre las

estructuras, que presentan una consistencia diferente con respecto a los usos estructurales, expuestos en el segundo epígrafe. Estos últimos se han relacionado con las notas distintivas que caracterizan las relaciones estructurales en cuanto a la relación entre los componentes y la totalidad, la dimensión que toman las estructuras con relación a las acciones individuales y el aspecto de la permanencia de este tipo de relaciones. A partir de todo ello, en el tercer epígrafe se han planteado las limitaciones para la exposición de las relaciones subyacentes y su interpretación dentro de un modelo estructural, ya que requiere de un marco teórico entre la economía y las disciplinas sociohistóricas, así como de una propuesta sobre la dinámica de todo ello. En el último punto, se exponen las conclusiones.

## 2. Las nociones de estructura en la realidad

Dentro de la tradición estructuralista, estas características se exponían en forma de analogías (anatómica, fisiológica y arquitectónica), de forma que su metodología se guiaba por las notas de totalidad –interpretación global del campo contemplado– e interdependencia entre los elementos integrados en esa unidad de conjunto, en la cual las relaciones estructurales se caracterizan por la nota de permanencia (Sampedro, 1959; Sampedro y Martínez, 1969). Es decir, por tener cierta estabilidad y no pertenecer a la coyuntura. El resultado es que en el ámbito ámbito económico, la estructura en términos amplios suele referirse a la disposición, orden u organización que toman las relaciones entre las partes con respecto a una propiedad o aspecto de una totalidad.

Como es conocido, lo expuesto guarda relación con las propuestas de Saussure sobre lingüística (las cuales se extendieron a las ciencias sociales e históricas), relacionadas con el carácter relacional de las totalidades, la naturaleza arbitraria del signo y la nota de diferencia (Giddens, 1990). A partir de todo ello, dentro de las ciencias sociales la estructura es considerada un término difícil de evitar (Sewell, 2005), debido a su fuerza retórica, a la hora de indicar aspectos relacionados con el orden de las relaciones, pese a la polisemia que lo caracteriza.

Todo lo anterior lleva a la coexistencia de definiciones muy diferentes entre sí con respecto a las estructuras, de forma que se ha optado por diferenciarlas en función de su compatibilidad con la economía convencional. A este respecto, si se considera la economía como una ciencia social particular (en contraste con una general), esta es capaz de aislar lo suficiente el conocimiento sobre los fenómenos como para que se hable de una autonomía de campo (Passeron, 2014). A falta de un término mejor, a esto se le ha llamado consenso sobre la economía convencional. Lo relevante es que dicha autonomía permite sostener una noción de sistema económico a la que referirse en términos de globalidad (Palazuelos: 2000). En estas condiciones, una noción de estructura que, en virtud de una serie de propiedades, expone la cosa observada a partir de sus aspectos esenciales como algo diferente a una acumulación, es algo que puede ser estudiado según Popper (2014) y que no presenta conflictos en cuanto

al espacio de prueba científica desde el punto de vista de la economía convencional.

De esta forma, aparece un conjunto de definiciones compatibles con la economía convencional y el individualismo metodológico que la caracteriza. Se trata de una noción que junto a sus usos se presenta como una herramienta flexible, capaz de seleccionar las relaciones entre las partes de un sistema económico en función del criterio utilizado para seleccionarlas. Dichos criterios de selección permiten reducir la diversidad y complejidad de agentes y actividades ha subconjuntos relativamente homogéneos (Hagemann, 2003). Con ellos se alcanza una descripción simplificada de la realidad que facilita la presentación de las relaciones.

Sin embargo, la compatibilidad se puede romper por dos vías. Por una parte, si se utilizan nociones de estructura que permiten trabajar dentro de la economía convencional, pero se asumen críticas que quiebran el consenso sobre la misma. Por otra, si las nociones de estructura que se manejan desbordan el marco de la economía convencional. Superar el marco ortodoxo les permite ampliar variables y relaciones al espacio de las ciencias sociales y del material histórico, pero con ello aparecen fuertes limitaciones, a la hora de encontrar mecanismos de validación de sus propuestas. En ambos casos, se produce una erosión de la autonomía del campo de conocimiento y ya no es posible sostener la idea de sistema económico a la que referirse en términos de globalidad.

Como consecuencia, aparece un segundo tipo de nociones de estructura. Sus enfoques se encuentran más relacionados con una concepción de la economía como ciencia social o cercana a la economía política. A este respecto, un primer grupo dentro de las mismas está compuesto por puntos de vista que integran los aspectos de la realidad económica con la de otras ciencias sociales, pero que no requieren de una síntesis sociohistórica. Un bloque aparte está compuesto por las nociones de estructura que superan la convención sobre el sistema económico, pero que refieren a algún tipo de síntesis teórica.

## 3. USOS ESTRUCTURALES

El segundo nivel está compuesto por los métodos que caracterizan el uso de algún tipo de noción de estructura a la hora de describir la realidad económica. Es decir, por los usos y métodos vinculados a los análisis estructurales. En este espacio entra en juego la forma de ubicar las interdependencias más permanentes entre las partes de la globalidad, dentro de la descripción de la realidad económica. Dada las diferencias de las nociones de estructuras, resulta difícil avanzar en los usos que las caracterizan de una forma unificada. Por ejemplo, el interés del estructuralismo por superar las transacciones y alcanzar los sujetos económicos, así como la voluntad de integrar la dimensión histórica de los procesos se distancia en los métodos utilizados con respecto a aquellos

usos que buscan la integración con la economía más convencional. Como consecuencia, se ha considerado más útil establecer las formas con las que se enfrentan las distintas nociones de estructura a los problemas habituales de su uso. A este respecto, se ha optado por destacar los vinculados a la interdependencia y la totalidad, a la dimensión que se ofrece al individuo y a la permanencia y las instituciones.

### 3.1. Componentes y totalidad

Uno de los conflictos habituales al trabajar con las relaciones se encuentra en la vinculación entre los componentes y la totalidad. Dado que las partes lo son de algo, un aspecto o una propiedad de la totalidad a la que se refieren, los usos estructurales fueron objeto de críticas por parte del individualismo metodológico o de las propuestas positivistas. En el primer caso, se debe a su percepción de la acción como exclusivamente individual, la cual lleva a desestimar cualquier acción colectiva que no sea resultado de la agregación de las llevadas a cabo por los individuos. En el segundo caso, debido a la imposibilidad de tener como objeto de estudio la totalidad de las totalidades, con la que se criticó las propuestas marxistas. Ambas coinciden en una condena al holismo, en la que se vio implicado el estructuralismo clásico.

A partir de estas consideraciones, surge una primera diferencia de importancia. La que existe entre los enfoques estructural y sistémico, debida a la mayor flexibilidad del primero a la hora de trabajar sobre las relaciones. Esta se encuentra relacionada con la necesidad de especificación de los aspectos relacionados con el fenómeno económico que requiere la construcción de un sistema, necesaria para establecer los isomorfismos entre el mismo y la realidad. Como consecuencia de ello también aparece una diferencia metodológica, vinculada a tipo de relaciones subyacentes que se pueden revelar. Mientras que en los sistemas, las necesidades de especificación (pese a que no sean completas) pueden predefinir el alcance del estudio, en el enfoque estructuralista *clásico* se revelan según se avanza en el estudio.

Dentro de este contexto, las investigaciones que buscan un mayor acomodo con la economía convencional, presentan la ventaja de acogerse a la noción de sistema económico en términos de totalidad. Sin embargo, como ya se ha mencionado anteriormente, con ello también se hacen sensibles a las críticas habituales a la economía convencional. Entre las que relaciona Martínez (2008) con los análisis parciales, se encuentran los problemas de la estilización y de la acotación del fenómeno económico (autonomía de conocimientos y pérdida del sentido del análisis en favor del uso de instrumentos formales), lo cual lleva a que esté indicada solo para relaciones significativas, intensas y relevantes.

Las nociones que se alejan de la economía convencional pierden la pretensión de un sistema definido de forma completa. Como consecuencia, en

función de la perspectiva que adopten se exponen gradualmente a mayores problemas con los sistemas y el holismo.

Las posiciones que entienden la economía como ciencia social (entre las que se ubican una buena parte los enfoques herederos del estructuralismo clásico), hablan de sistemas abiertos frente a sistemas cerrados. A estos últimos los relacionan con la necesidad de identificar completamente todos los aspectos relevantes del fenómeno económico, como las variables endógenas y exógenas, los límites, las relaciones, los componentes y la estructura entre los mismos, así como la naturaleza de los agentes económicos, que son tratado de forma atomista (Chick, 2004; Chick y Dow, 2005). Sin embargo, conviene rechazar una dicotomía o dualismo que enfrente el sistema cerrado y la modelización con el sistema abierto y la imposibilidad de la formalización. Un sistema de ideas abierto puede producir diferentes modelizaciones, pero sobre todo, la apertura de los sistemas está relaciona con el incumplimiento de una o más de las condiciones que se requieren en los cerrados.

Como consecuencia, surgen aspectos que avalan el tratamiento de los sistemas de forma abierta tanto desde la realidad como desde los enfoques teóricos. Sin embargo, la apertura ontológica que supone la percepción de la realidad social como un sistema abierto, no impide que como sistema tenga estructuras parciales y provisionales, que además permiten el desarrollo de estructuras teóricas.

Por otro lado, la diferencia entre los sistemas cerrados y abiertos incide en la diferencia que presentar a la hora de trabajar. La metodología de la economía convencional evoluciona con axiomas fuerzas externas e internas completamente especificadas. Por el contrario, los sistemas abiertos trabajan con incertidumbre y mutabilidad. En este punto, la consistencia entre la percepción de la realidad y la metodología aparece como elemento crítico del enfoque de investigación, que además determina el alcance del mismo.

En el otro extremo quedan las ontologías que pretendan abrirse a una totalidad de la realidad, así como las que aspiran a la construcción de un sistema abierto que lo contemple, ya que son capaces de resucitar los fantasmas del holismo.

### 3.2 La acción individual y el orden de las relaciones

Un segundo problema de carácter recurrente en los usos estructurales se deriva de la forma con la que se aborde la acción y la decisión individual, así como de su encaje con las estructuras. En el estructuralismo clásico el punto de vista se puede observar en la exposición de las limitaciones que presentan las interdependencias captadas a través de las transacciones y en la voluntad de trascenderlas para alcanzar los sujetos económicos (Sampedro, 1959). De esta forma, aparece la crítica al individualismo metodológico y a las limitaciones que presenta con respecto al fragmento de la realidad que observa o al tipo de racionalidad estrecha con que lo hace, entre otras cuestiones. El problema se

encuentra en el margen que se ofrece a la acción individual dentro del estructuralismo, ya que en las explicaciones sobre las relaciones la acción individual queda ausente de las mismas. Se trata de un problema conocido en las ciencias sociales como conflación descendente, en el cual la acción individual queda solamente explicada a partir de las estructuras, el cual dio lugar a varios cambios en los términos de los debates.

En contraste, las posiciones más cercanas a la economía convencional, presentan las estructuras como resultados de las interacciones entre los individuos, de forma que las propiedades y poderes causales a los que se puedan referir deben encontrarse en ellos. Como consecuencia, se presenta una conflación ascendente, en la que las estructuras solo son observadas como resultados de la acción individual.

Frente a ello, la aceptación de una ontología social abierta por parte de las posturas que insisten en la economía como una ciencia social, encuentran entre sus elementos definidores la necesidad de exponer la relación que existe entre las estructuras y la acción individual. Este aspecto, parece que se ha trasladado desde la teoría social, en la que la insatisfacción sobre los enfoques de las estructuras y de la agencia revelaron la existencia de la conflación y de diferencias ontológicas entre ellas.

Como consecuencia de ello, se han desarrollado las propuestas de la estructuración y de la morfogénesis dentro de la teoría social, en las que se ha intentado aunar la presencia de estructuras y de la acción individual en la misma realidad social. A este respecto, las propuestas procedentes del realismo crítico han sido capaces de superar las limitaciones que presentaba el estructuralismo clásico, pero a través de la presentación de una realidad estratificada, en la cual las acciones y poderes causales de las entidades colectivas no se consideran completamente reducibles a las de las acciones individuales.

Dentro de este marco, las estructuras en cuanto ordenes de relaciones son las que determinan la forma en la que los elementos se reúnen como componentes de un aspecto de la totalidad. Como consecuencia, totalidad y estructura emergen de manera simultánea (Lawson, 2013). Con respecto a la relación entre la acción individual y las estructuras, las propuestas de la morfogénesis resultan de particular interés dentro de la economía. Según estas, los individuos son los que realizan las interacciones, pero desde estructuras en las que se encuentran inmersos y que son anteriores a las acciones. Dichas interacciones moldean los órdenes de las relaciones, de forma que pueden reproducirlos, cambiarlos o cancelarlos, lo que da como resultado una elaboración estructural (Archer, 2009). En este punto, la dimensión temporal de los usos estructurales toma importancia y con ello la nota de permanencia de las relaciones.

### 3.3. Permanencia

La última de las notas que caracterizaba los análisis estructurales se refiere al mayor interés que presentaban las relaciones más permanentes, las cuales tienen una mayor capacidad de definición del sistema económico (Sampedro, 1959). Con ellas se hace referencia a la persistencia de un determinado orden de las relaciones, a la reproducción de las estructuras si se quiere.

Esta característica permite diferenciar el análisis estructural de la coyuntura he incide en la búsqueda de las relaciones subyacentes, pero ha presentado un alcance muy limitado dentro de la economía convencional. Su uso como herramienta de descripción de las relaciones estructurales se ha confundido con los aspectos económicos de largo plazo o de los fundamentos, y no parece haber ofrecido un gran margen a los estudios. De una parte, en cuestiones de largo plazo no ha conseguido alcanzar un marco de relación fluido con la historia económica. De otra parte, la preeminencia de las relaciones macroeconómicas de corto plazo ha oscurecido su capacidad para elaborar propuestas. Uno de los aspectos en los que se cristaliza este problema se encuentra en el estudio las instituciones, donde las propuestas sobre bienes comunes y la nueva economía institucional han desdibujado el margen para su estudio ofrecido desde las estructuras.

En el otro extremo, las propuestas que mantienen una ontología abierta a los aspectos sociohistóricos, pero que mantienen la antigua aspiración a la construcción de algún tipo de síntesis, se encuentran lastradas por los problemas del estructuralismo clásico a este respecto. Las dificultades se encuentran en la necesidad de disponer de un modelo estructural para revelar en su completitud las relaciones estructurales subyacentes y, por tanto, pertenecen al tercer nivel de análisis. La cuestión es que, con esta metodología, la posibilidad de identificar relaciones estructurales y de profundizar en aspectos institucionales queda sujeta a la interpretación dinámica y sintética. Sin posibilidad de la misma, queda como un análisis necesariamente incompleto.

Entre las dos posiciones anteriores, quedan las metodologías que pueden desarrollar las ontologías abiertas (en algún grado a aspectos sociales e históricos) con sistemas abiertos en torno a las relaciones con mayor permanencia. En realidad, se trata de uno de los puntos que más interés presenta desde el punto de vista metodológico, ya que la combinación entre relaciones estructurales y propuestas sobre sistemas abiertos permiten revelar en mayor medida las interacciones que produce un orden de las relaciones económicas con otros componentes de la realidad. En cualquier caso, el acercamiento al largo plazo y a las instituciones introduce el problema de la relación con los aspectos históricos, que se tratan desde el análisis de la dinámica.

## 4. cambio, dinámica y modelo estructural

La aproximación a las instituciones y a las relaciones entre estas y las estructuras debe atender al sentido histórico. Esto no es fruto de la casualidad, sino del

acercamiento gradual al modelo estructural. Éste es el que debe revelar las estructuras de los procesos en los cuales tienes lugar las transformaciones, que son interpretadas por parte de la dinámica estructural. Aquí es donde se concretan los conflictos y límites de las distintas propuestas sobre el cambio económico y social que incorporan los diferentes enfoques. En consecuencia, se trata de espacio de mayor aspiración del estructuralismo clásico, pero también el que mayores limitaciones presentó. En lo apuntado planean los problemas relacionados con la reconstrucción de las relaciones y su interpretación, a través de un paradigma teórico a la vez sintético y dinámico, reclamado por autores como Levi Strauss o Beiras. De él surgen dos viejos debates sin una solución clara: la delimitación de las relaciones entre la economía y las disciplinas sociohistóricas y la posibilidad de desarrollo de una teoría del cambio.

Desde el entorno que asumió la economía como una ciencia social particular, se considera que el desarrollo metodológico ha trascendido los límites tradicionales de la disciplina. Con ello se plante un sentido de la economía (Rodrik, 2016) como forma de trabajo en las ciencias sociales, asociada a los modelos formales y el análisis estadístico. De esta manera, la adopción del formalismo y de la lengua artificial que la acompaña actúan como un mecanismo para evitar los problemas que crea el uso de las lenguas naturales en las ciencias sociales. Pero junto a ello, la aspiración a establecer modelos estructurales que expliciten completamente las relaciones estructurales que tienen lugar reposa en el olvido.

Por su parte, en las disciplinas sociohistóricas se constata desde tiempo atrás una convergencia, la cual se puede observar bajo diferentes ópticas (Tilly, 2007). La percibida por Burke como la convergencia de la historia y de la teoría, supone abrir los métodos y contenidos de la historia a los instrumentos descriptivos y explicativos de las disciplinas sociales. Particularmente a aquellos que resultan más efectivos para el trabajo histórico. Por su parte, la convergencia asumida desde las disciplinas sociales está marcada por los avances sobre las relaciones entre agencia y estructura. La tercera vía para observar la convergencia está marcada por su carácter constructivista, en la que se aboga por el estudio sistemático de los efectos del contexto, centrado en las relaciones entre personas, grupos y procesos.

A este respecto, las opciones compatibles con la economía convencional han optado por hablar de cambio estructural antes que de dinámica, al tiempo que su literatura se ha concentrado en las innovaciones (Silva y Teixeira, 2008). Por su parte, las posiciones con mayor cercanía con las aspiraciones estructuralistas clásicas de un modelo estructural, han intentado superar propuestas como las del enfoque histórico estructural. En consecuencia, han intentado proponer reconstrucciones de las relaciones entre las disciplinas sociales e históricas desde el realismo crítico o desde el constructivismo (Lloyd, 2013, 2008; Tilly, 2007). Sin embargo, ante las dificultades que presenta tal tipo de proyecto, se prefiere hablar de un dominio conjunto de conocimientos. El espacio que queda entre ambos extremos se abre a la interpretación de las

relaciones estructurales desde otros enfoques, con un reconocimiento del pluralismo metodológico (Bárcena y Prado, 2015), pero el alcance de estas posiciones en términos de conocimientos queda en algún punto indeterminado.

## 4. Conclusiones

A lo largo de este trabajo se han intentado exponer los principales cambios que han sufrido las nociones de estructura y los usos que las acompañan. A lo largo de este proceso, se ha hecho evidente que existen un conjunto de estudios que tienden a utilizar las estructuras dentro de análisis de economía convencional. Esto les permite no entrar en conflicto con el individualismo metodológico ni con los espacios de prueba científica, pero los hace sensibles a las críticas a la economía que ya se exponían por parte del estructuralismo clásico. No presentan conflictos con respecto a la totalidad a la que se refieren, ya que es la del sistema económico, pero están caracterizadas por una conflación ascendente, al ser resultado de las agregaciones individuales. Ante tales limitaciones, sus aportaciones en este contexto resultan escasas, como se observa en el caso de las instituciones. En cualquier caso, el espacio que estas nuevas formas de integrar las estructuras quedan sujetas a la relación que ofrezcan estas formas de entender la economía a las disciplinas sociohistóricas.

En el extremo opuesto se encuentran las ontologías abiertas que mantienen en algún grado la aspiración a una construcción teórica que integre el espacio económico con el de las ciencias sociales y la historia. Heredan buena parte de las propuestas realizadas por parte del estructuralismo más clásico, de forma que pueden reclamar sus diferencias con respecto a las propuestas sistémicas y aun superar algunas deficiencias con respecto al papel que ofrecen a la acción individual. Sin embargo, la necesidad de presentar algún tipo de síntesis sociohistórica lastra su alcance.

Entre ambas posiciones se encuentra el que posiblemente sea el espacio más fructífero. En él se asume la existencia de una ontología social abierta y las estructuras se integran como parte constitutiva de sistemas abiertos en los planos reales y teóricos. Con ello se superan las limitaciones de los enfoques con respecto a la formalización y se evitan las críticas sobre la acción individual, gracias a las propuestas sobre relación entre estas últimas y las estructuras. Estas aperturas permiten recuperar parte de las propuestas estructuralistas clásicas acerca de las relaciones con otras disciplinas sociales, pero requieren el abandono de la aspiración a una teoría sociohistórica, a un paradigma estable que permita hablar de una ciencia normal al modo de Khun, al menos en lo que se refiere al manejo del material histórico.

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## 4.2 D2. A new perspective on the Global Innovation Index: A panel data analysis - Marcelo Duarte, Fernando Carvalho

**A new perspective on the Global Innovation Index: A panel data analysis**

**Uma nova perspetiva sobre o Índice de Inovação Global: Uma análise de dados em painel**

**Una nueva perspectiva sobre el Índice de Innovación Global: Un análisis de datos de panel**

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Abstract
Among the most used innovation indices, the Global Innovation Index stands out by explicitly distinguishing innovation inputs and outputs. However, few researches has been done regarding the relationship between innovation inputs and outputs. Although a positive relationship between them seems obvious, we argue that different inputs could have differentiated effects on innovative outputs. Therefore, we developed a panel data set based on the Global Innovation Index, composed by 112 countries during the period 2013-2018, and analysed it through a series of multiple regression techniques. Results suggest that aggregated innovation inputs have a positive relationship with outputs. However, when disaggregating down to the pillar level, we found that some pillars have strong positive effects on innovation outputs, while others appear to indicate negative relationships.
Keywords: National systems of innovation; Global Innovation Index; innovation inputs; innovation outputs; panel data.
JEL classification: C33; C67; O30; O38.

Resumo
De entre os índices de inovação mais utilizados, o Índice de Inovação Global destaca-se pela distinção explicita entre *inputs* e *outputs* de inovação. No entanto, existem poucos estudos realizados sobre a relação entre *inputs* e *outputs* de inovação. Embora uma relação positiva entre eles pareça óbvia, nós argumentamos que diferentes *inputs* podem ter efeitos diferenciados sobre os *outputs*. Assim, desenvolvemos uma base de dados em painel baseada no Índice de Inovação Global, composta por 112 países durante o período de 2013-2018, analisando-a através de diversas técnicas de regressão múltipla. Os resultados sugerem que os *inputs* de inovação agregados têm uma relação positiva com os *outputs*. No entanto, analisando com uma maior desagregação, descobrimos que alguns pilares têm fortes efeitos positivos nos *outputs* de inovação, enquanto que outros parecem indicar relações negativas.
Palavras-chave: Sistemas nacionais de inovação; Índice de Inovação Global; *inputs* de inovação; *outputs* de inovação; dados em painel.

Resumen
Entre los índices de innovación más utilizados, el Índice de Innovación Global se destaca al distinguir explícitamente los *inputs* y *outputs* de innovación. Sin embargo, existen pocos estudios realizados sobre la relación entre inputs y outputs de innovación. Aunque una relación positiva entre ellos parezca obvia, argumentamos que diferentes *inputs* podrán tener efectos diferenciados en los outputs. Por lo tanto, desarrollamos una base de datos de panel basado en el Índice Global de Innovación, compuesto por 112 países durante el período 2013-2018, y lo analizamos a través de técnicas de regresión múltiple. Los resultados sugieren que los *inputs* de innovación agregados tienen una relación positiva con los *outputs*. Sin embargo, analizando con una mayor desagregación, descubrimos que algunos pilares tienen fuertes efectos positivos en los *outputs* de innovación, mientras que otros parecen indicar relaciones negativas.
Palabras-clave: Sistemas nacionales de innovación; Índice de Innovación Global; *inputs* de innovación; *outputs* de innovación; datos de painel.

## 1. Introduction

National Systems of Innovation (NSI) are recognized as cornerstones for countries' international competitiveness (Fagerberg & Srholec, 2008; Freeman, 1987, 1995; Furman, Porter, & Stern, 2002; Lundvall, 1992; Nelson, 1993), being broadly defined as "all important economic, social, political, organisational, institutional, and other factors that influence the development, diffusion, and use of innovations" (Edquist, 2005: 182). This definition highlights the essentially systemic nature of innovation, involving both organisations and policymakers in the innovation process within a nation. In fact, the United Nations recognized innovation as key to economic development by including it in its Sustainable Development Goals (UN, 2015).

In order to improve a country's innovative capacities, policy decisionmakers must be able to understand which factors are driving innovation within their economies (Kuhlmann et al., 1999), because, as any given manager would say, you can't manage what you can't measure. Therefore, it becomes necessary to find ways of measuring the investment made in NSI and the resulting outcomes of such investments (Borrás & Laatsit, 2019). To that end, several international institutions have developed frameworks to analyse the innovation readiness of countries, such as the European Innovation Scoreboard (EIS, 2018), the Nordic Innovation Annual Report (NIAR, 2018), the OECD Science, Technology and Innovation Scoreboard (STI, OECD, 2017) and the Global Innovation Index (GII, Cornell University et al., 2018).

In this paper, we make use of the GII due to its clear distinction between innovation inputs and outputs, based on 80 comparable indicators (Cornell University et al., 2018). The index, besides being developed by major international institutions, is audited by European Commission's Joint Research Centre to attest its statistical validity. Thus, can be used as a leading reference for policymakers, business executives, as well as for researchers (Sohn, Kim, & Jeon, 2016). The GII 2018 (Cornell University et al., 2018) covers 126 countries using two sub-indices of innovation inputs and outputs. Under the input sub-index are five pillars, consisting in institutions, human capital and research, infrastructure, market sophistication, and business sophistication, while the output sub-index is divided into two pillars of knowledge and technology outputs, and creative outputs.

By using a panel data set based on the GII from 2013 to 2018, we intend to analyse the relationship between innovation inputs and outputs, in order to understand which inputs have a greater contribution to innovative outputs, thus, deepening policymakers reasoning on the subject.

In the following section, we make a brief description of the GII and its components, followed by a literature review and proposed hypothesis. Next, we describe the methodology used, revealing and discussing the results obtained. Lastly, we conclude with relevant findings, academic and policy contributions, as well as proposals for future research.

## 2. Literature review and hypothesis

The NSI approach was introduced in the 1980s (see Freeman, 1995; Lundvall, 2007) and, since then, numerous studies were developed in an attempt to measure and compare such systems (Erciş & Ünalan, 2016; Fernandez Donoso, 2017; Furman et al., 2002; Kwon, Kim, & Koh, 2016; Niosi, Saviotti, Bellon, & Crow, 1993; Patel & Pavitt, 1994; Porter & Stern, 1999; Sohn et al., 2016). The impact of such systems on international competitiveness (Furman et al., 2002; Nelson, 1993) led to the creation and widespread use of various indicators by major international organizations, such as the EIS (EIS, 2018), the NIAR (NIAR, 2018), the OECD STI Scoreboard (OECD, 2017) and the GII (Cornell University et al., 2018). Such indicators are often developed to characterise and compare countries' NSI, lacking the distinction between inputs and outcomes of such systems, thus impeding the assessment of innovation efficiency, which, according to Cruz-Cázares, Bayona-Sáez, & García-Marco (2013), is the best measure of innovation.

The notion that innovation inputs are transformed into innovative outputs is a very straightforward one, Cornell University et al. (2018) describe a positive relationship between innovation inputs and outputs in every income groups, hence we propose the following hypothesis.

H1: Innovation inputs have a positive relationship with innovation outputs.

Following North's (1990: 360) definition of institutions as “humanly devised constraints that structure human interaction”, or simply as “the rules of the game”, it is probable that such rules can encourage creative behaviour of individuals and organisations within an economy, thus promoting innovative activities. For instance, using patent grant data, Tebaldi & Elmslie (2013) found that institutional quality is positively related to patent count across countries. On another study with a large sample of advanced and emerging economies, Silve & Plekhanov (2015) found that institutions are important determinants of innovation and, further still, that industries involving higher levels of innovation develop faster in countries with better economic institutions. Using GII data, Sohn et al. (2016) found a positive and indirect relationship between institutions and both knowledge and technological outputs and creative outputs. Therefore, we propose the following hypothesis.

H2a: Institutions have a positive relationship with innovation outputs.

H2b: Institutions have a positive relationship with knowledge and technology outputs.

H2c: Institutions have a positive relationship with creative outputs.

Human capital and research refers to the countries’ level of education and research. Van Hiel et al. (2018), using a large sample of countries with great variation in terms of Human Development Index (HDI), found that increasing levels of education, in high HDI countries, translates into better scores on national indices of innovation through the increase of liberalization values in such societies. Also, Suseno, Standing, Kiani-Mavi, & Jackson (2018) found that human capital, as well as social capital, have a significant effect on national innovation performance. Regarding the role of research on innovation, Bilbao-Osorio & Rodriguez-Pose (2004) conclude that overall R&D activities are positively related to innovation in the European Union (EU), while public funded R&D is more related to innovation than private R&D in peripheral regions of the EU. Sohn et al. (2016) found positive direct and indirect relationships between human capital and research and both output pillars. Such empirical evidence leads us to propose the following hypothesis.

H3a: Human capital and research have a positive relationship with innovation outputs.

H3b: Human capital and research have a positive relationship with knowledge and technology outputs.

H3c: Human capital and research have a positive relationship with creative outputs.

According to Cornell et al. (2018: 59) “good and ecologically friendly communication, transport, and energy infrastructures facilitate the production and exchange of ideas, services and goods”. For example, Cuevas-Vargas, Estrada, & Larios-Gómez (2016) found that the use of ICTs is a critical facilitator of innovation for micro, small, and medium sized enterprises in Mexico. Also, Martins & Veiga (2018) conclude that innovations in Portugal’s electronic government can lead to a more business-friendly environment, by reducing the administrative and regulatory burden. According to Sohn's et al. (2016) research, infrastructure has an indirect, positive, relationship with the two output pillars. Therefore, we propose the following hypothesis.

H4a: Infrastructure have a positive relationship with innovation outputs.

H4b: Infrastructure have a positive relationship with knowledge and technology outputs.

H4c: Infrastructure have a positive relationship with creative outputs.

Economic and finance literatures reveal a relationship between financial markets’ development and economic growth (Beck & Levine, 2002; King & Levine, 1993; La Porta, Lopez-de-Silanes, Shleifer, & Vishny, 1998). Fagerberg & Srholec (2008) stressed the importance of a country’s financial system in mobilizing the necessary resources for innovation. Empirically, based on a three decade panel of U.S. issued patents, Kortum & Lerner (2000) found that venture capital has a positive and significant impact on technological innovation. Also, Sohn et al. (2016) discovered a positive direct relationship between this pillar and both output pillars. Thus, we propose the following hypothesis.

H5a: Market sophistication have a positive relationship with innovation outputs.

H5b: Market sophistication have a positive relationship with knowledge and technology outputs.

H5c: Market sophistication have a positive relationship with creative outputs.

Business sophistication pillar refers to knowledge workers (i.e. human capital employed by businesses), innovation linkages (i.e. linkages and partnerships between private, public and academic actors), and knowledge absorption (i.e. all high-tech and ICTs imports, intellectual property payments, FDI inflows, and researchers in business enterprises) (Cornell et al., 2018). For instance, Love & Mansury (2007), studying US business services, found that a highly qualified working force increases the probability of innovation. The authors also found that external linkages improve innovation performance. A study on Italian firms conducted by Maietta (2015) suggests that R&D collaboration between firms and universities have an impact on process innovation and a positive effect on product innovation for firms geographically closer to such entities. Also, Díez-Vial & Montoro-Sánchez (2016) found a positive relationship between the knowledge obtained by technology firms from universities and their levels of innovation. Regarding knowledge absorption, Liu & Zou (2008) found that R&D greenfield FDI significantly affects the innovation performance of domestic firms, finding evidence of both intra- and inter-industry spillovers. Also, Bertschek (1995) and Blind & Jungmittag (2004) found that both imports and inward FDI have positive and significant effects on product and process innovations. Again, Sohn et al. (2016) discovered a positive direct relationship between the business sophistication pillar and both output pillars. In this sense, we propose the following hypothesis.

H6a: Business sophistication have a positive relationship with innovation outputs.

H6b: Business sophistication have a positive relationship with knowledge and technology outputs.

H6c: Business sophistication have a positive relationship with creative outputs.

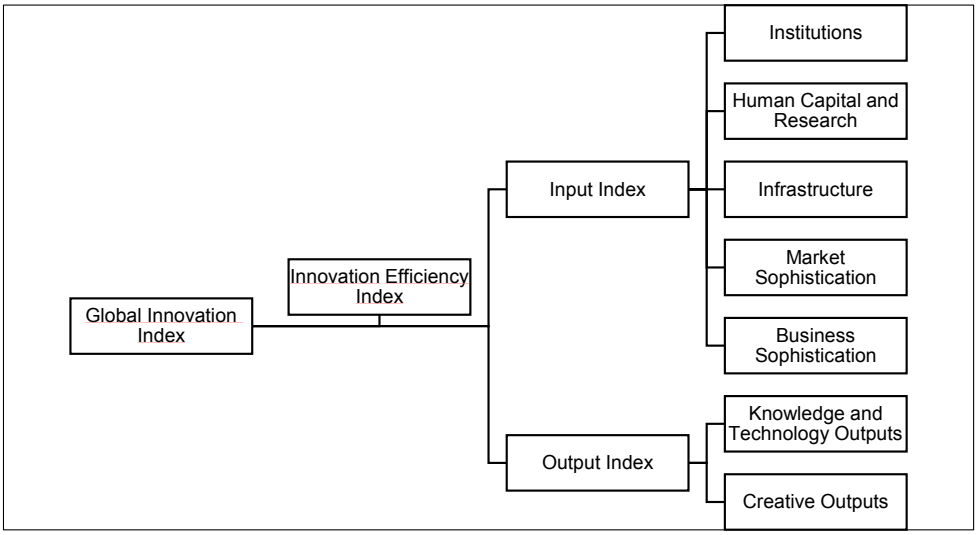
## 2.1. Global Innovation Index

The Global Innovation Index (GII) was launched in 2007 by INSEAD to shed light on the measurement of innovation readiness of countries and to find means of generating meaningful comparisons (Dutta, INSEAD, & Caulkin, 2007), helping business leaders and public policymakers to understand the reasons of a nation's relative performance (Dutta, 2009).

The GII framework relies on the distinction between inputs and outputs to measure innovation in an economy, being inputs the elements of the national economy that

enable innovative activities, and outputs the results of innovative activities within the economy. Both inputs and outputs sub-indices are then divided in five input pillars (Institutions, Human Capital and Research, Infrastructure, Market Sophistication, and Business Sophistication) and two output pillars (Knowledge and Technology Outputs, and Creative Outputs). Each of the seven pillars is composed by three sub-pillars, which are, in turn, composed by a total of 80 indicators (Cornell University et al., 2018). A weighted average of the standardized indicators forms the sub-pillars' scores, which, with a simple average, form the pillars' scores. The input sub-index is obtained through a simple average of the five input pillars and output sub-index from a simple average of the two output pillars. The final GII results from the simple average of input and output sub-indices. The framework also includes an Innovation Efficiency Index, which is the ratio of the output sub-index over the input sub-index, showing how much innovation outputs a country is obtaining for its inputs. Figure 1 shows the GII framework up to the sub-pillar level and the indicators used in the GII 2018 are reported in appendix 1.

Figure 1: Global Innovation Index framework




Source: Cornell University et al. (2018)

The index resorts to several sources of data, which are of three types: hard data, composite indicators, and survey questions World Economic Forum's Executive Opinion Survey (EOS). The indicators are then normalized using a min-max approach.

In order to ensure cross-country comparability, some indicators required scaling. When the scale factor used was GDP, the purchasing power parity (PPP) in international dollars was used.

## 3. Methodology

### 3.1. Data and sample

To test the proposed hypothesis, we developed a panel data set of GII scores at the pillar level on 112 countries[1], which in 2017 corresponded to 95.51% of the world GDP (PPP, current international $), during the period of 2013 to 2018. The variables collected are shown in table 1.

Table 1: Variables description

| | Variable | Code | Description |
|---|---|---|---|
| | Innovation Input Sub-Index | Iin | Simple average of the five input pillars. |
| | Innovation Output Sub Index | Iout | Simple average of the two output pillars. |
| **Input pillars** | Institutions | I1 | Captures the institutional framework of a country. |
| | Human Capital and Research | I2 | Gauges the human capital of countries. |
| | Infrastructure | I3 | Captures ecologically friendly communication, transport, and energy infrastructures. |
| | Market Sophistication | I4 | Captures market conditions and total level of transactions. |
| | Business Sophistication | I5 | Assesses how conducive firms are to innovation activity. |

[1] Albania, Algeria, Argentina, Armenia, Australia, Austria, Azerbaijan, Bahrain, Bangladesh, Belarus, Belgium, Bolivia, Bosnia and Herzegovina, Brazil, Bulgaria, Burkina Faso, Cambodia, Cameroon, Canada, Chile, China, Colombia, Costa Rica, Cote d'Ivoire, Croatia, Cyprus, Czech Republic, Denmark, Dominican Republic, Ecuador, Egypt, El Salvador, Estonia, Finland, France, Georgia, Germany, Greece, Guatemala, Honduras, Hong Kong, Hungary, Iceland, India, Indonesia, Iran, Ireland, Israel, Italy, Jamaica, Japan, Jordan, Kazakhstan, Kenya, Republic of Korea, Kuwait, Kyrgyz Republic, Latvia, Lebanon, Lithuania, Luxembourg, Madagascar, Malaysia, Mali, Malta, Mauritius, Mexico, Moldova, Mongolia, Montenegro, Morocco, Mozambique, Netherlands, New Zealand, Nigeria, Norway, Oman, Pakistan, Panama, Paraguay, Peru, Philippines, Poland, Portugal, Qatar, Romania, Russian Federation, Rwanda, Saudi Arabia, Senegal, Serbia, Singapore, Slovak Republic, Slovenia, South Africa, Spain, Sri Lanka, Sweden, Switzerland, Tajikistan, Tanzania, Thailand, FYRO Macedonia, Tunisia, Turkey, Uganda, Ukraine, United Arab Emirates, United Kingdom, United States of America, Uruguay, and Viet Nam.

| | | | |
|---|---|---|---|
| **Output pillars** | Knowledge and Technology Outputs | O6 | Covers all variables traditionally linked to inventions and/or innovations. |
| | Creative Outputs | O7 | Measures the role of creativity for innovation. |

Source: Cornell University et al. (2013, 2014, 2015, 2016, 2017, 2018)

To develop a panel based on GII data and assure comparability throughout the years, we had to address some of the report's methodological shortcomings. First, we choose 2013 as the first year since previous GII reports used a different scale to measure countries' scores, as well as different pillars. Second, since the number of countries included in the reports varied throughout the years[2], mainly due to missing values, we adopted a similar approach of Cornell University et al. (2018) when dealing with missing values: in each year, we dropped the countries which had less than 66% of the total input indicators and less than 66% of the total output indicators; then, we dropped countries which did not have values for all years. This way, we have obtained a balanced panel with 672 country-year observations. Third, some caution is used when discussing the results due to methodological changes at the indicator level throughout the years.

## 3.2. Variables

### 3.2.1. Dependent variables

To analyse the relationship between innovation inputs and outputs, we used three dependent variables in separate models. First, the output sub-index (Iout) is used to assess the effect of inputs on the overall score of innovation outputs. Then, we used the two output pillars (knowledge and technology outputs (O6) and creative outputs (O7)) to further investigate the effects of innovation inputs in both outcomes.

### 3.2.2. Independent variables

The explanatory variables used are the innovation input sub-index (Iin) and the five input pillars, institutions (I1), human capital and research (I2), infrastructure (I3), market sophistication (I4), and business sophistication (I5).

[2] 142, 143, 141, 128, 127, and 126 countries in 2013, 2014, 2015, 2016, 2017, and 2018, respectively.

3.3. Model specification

When conducting linear regressions with panel data, several estimators could be used, being the most common the pooled ordinary least squares (pOLS), the fixed effects estimator (FE), and the random effects estimator (RE) (Baltagi, 2015; Wooldridge, 2016). To choose a model, one must consider the nature and source of the data, as well as the methodology used to obtain it (for a discussion, see Hsiao, 2007). Apart from the theoretical discussion, a set of statistical tests can be used to choose a particular model, namely an F test on the joint significance of differing group means (H0 = pOLS; H1 = FE), a Breusch-Pagan test using a Lagrange Multiplier (H0 = pOLS; H1 = RE), and a Hausman test (H0 = RE; H1 = FE).

In this sense, we developed four models in both pOLS and FE specification. The RE specification was not used, since all relevant statistical tests indicated that a FE approach was appropriate. Therefore, to test hypothesis H1, we developed the following models:

$$(1) \qquad lout_{it} = \beta_0 + \beta_1 lin_{it} + \delta_1 d14_t + \delta_2 d15_t + \delta_3 d16_t + \delta_4 d17_t + \delta_5 d18_t + \alpha_i + \mu_{it}$$

$$(2) \qquad lout_{it} = \beta_1 lin_{it} + \delta_1 d14_t + \delta_2 d15_t + \delta_3 d16_t + \delta_4 d17_t + \delta_5 d18_t + \alpha_i + \mu_{it}$$

Where, lout is the dependent variable for each individual ($i$) in each period ($t$), $\beta_0$ is the intercept, $\beta_1$ is the slope of the variable of interest, $\delta_k$ (K=1,2,3,4,5) are the coefficients of year dummies included in the regression, $\alpha_i$ is the individual fixed effect that does not vary over time, and $\mu_{it}$ is the idiosyncratic error. We follow Wooldridge (2016) recommendation to include time dummies, if T is small relative to N (in this case, T=6 and N=112), to capture secular changes that are not being modelled. Eq. 1 refers to the pOLS specification. Eq. 2 to the FE specification, which does not include a constant.

To test hypothesis H2a, H3a, H4a, H5a, and H6a, we developed the following models:

$$(3) \qquad lout_{it} = \beta_0 + \beta_1 l1_{it} + \beta_2 l2_{it} + \beta_3 l3_{it} + \beta_4 l4_{it} + \beta_5 l5_{it} + \delta_1 d14_t + \delta_2 d15_t + \delta_3 d16_t + \delta_4 d17_t + \delta_5 d18_t + \alpha_i + \mu_{it}$$

$$(4) \qquad lout_{it} = \beta_1 l1_{it} + \beta_2 l2_{it} + \beta_3 l3_{it} + \beta_4 l4_{it} + \beta_5 l5_{it} + \delta_1 d14_t + \delta_2 d15_t + \delta_3 d16_t + \delta_4 d17_t + \delta_5 d18_t + \alpha_i + \mu_{it}$$

Eq. 3 refers to the pOLS specification and Eq. 4 to the FE. Here, the explanatory variables of interest are the five input pillars.

The following models were developed to test hypothesis H2b, H3b, H4b, H5b, and H6b:

$$(5) \quad O6_{it} = \beta_0 + \beta_1 I1_{it} + \beta_2 I2_{it} + \beta_3 I3_{it} + \beta_4 I4_{it} + \beta_5 I5_{it} + \delta_1 d14_t + \delta_2 d15_t + \delta_3 d16_t + \delta_4 d17_t + \delta_5 d18_t + \alpha_i + \mu_{it}$$

$$(6) \quad O6_{it} = \beta_1 I1_{it} + \beta_2 I2_{it} + \beta_3 I3_{it} + \beta_4 I4_{it} + \beta_5 I5_{it} + \delta_1 d14_t + \delta_2 d15_t + \delta_3 d16_t + \delta_4 d17_t + \delta_5 d18_t + \alpha_i + \mu_{it}$$

Where Eq. 5 refers to the pOLS specification and Eq. 6 to FE.

Lastly, to test hypothesis H2c, H3c, H4c, H5c, and H6c, we developed the following models:

$$(7) \quad O7_{it} = \beta_0 + \beta_1 I1_{it} + \beta_2 I2_{it} + \beta_3 I3_{it} + \beta_4 I4_{it} + \beta_5 I5_{it} + \delta_1 d14_t + \delta_2 d15_t + \delta_3 d16_t + \delta_4 d17_t + \delta_5 d18_t + \alpha_i + \mu_{it}$$

$$(8) \quad O7_{it} = \beta_1 I1_{it} + \beta_2 I2_{it} + \beta_3 I3_{it} + \beta_4 I4_{it} + \beta_5 I5_{it} + \delta_1 d14_t + \delta_2 d15_t + \delta_3 d16_t + \delta_4 d17_t + \delta_5 d18_t + \alpha_i + \mu_{it}$$

Where Eq. 7 refers to pOLS specification and Eq. 8 to FE.

### 3.4. Descriptive statistics

Tables 2 and 3 shows the main descriptive statistics and the correlation matrix with the variance inflation factors (VIF), respectively. An analysis of the correlation matrix reveals the existence of correlations between the variables. Although a high correlation was expected between the input and output sub-indexes and their respective pillars, the existing correlations between the five input pillars could result in multicollinearity issues when regressed together. However, the highest VIF value (5.368) is below the common rule of thumb of 10 (Wooldridge, 2016), which indicates that multicollinearity should not be a problem.

Table 2: Descriptive statistics.

| Variable | N | Mean | Std. Dev. | Minimum | Maximum |
|---|---|---|---|---|---|

| | | | | | |
|---|---|---|---|---|---|
| **Iout** | 672 | 32.72 | 11.66 | 8.30 | 68.63 |
| **O6** | 672 | 29.74 | 12.52 | 5.30 | 74.88 |
| **O7** | 672 | 35.69 | 12.62 | 0.56 | 73.74 |
| **Iin** | 672 | 45.87 | 11.65 | 23.68 | 74.23 |
| **I1** | 672 | 65.27 | 15.59 | 29.18 | 95.85 |
| **I2** | 672 | 35.23 | 14.87 | 7.12 | 73.28 |
| **I3** | 672 | 43.47 | 12.81 | 11.38 | 69.54 |
| **I4** | 672 | 49.90 | 11.09 | 28.23 | 88.58 |
| **I5** | 672 | 35.47 | 11.06 | 12.64 | 69.16 |

Source: Authors.

Table 3: Correlation matrix and variance inflation factors.

| | **VIF** | **Iout** | **O6** | **O7** | **Iin** | **I1** | **I2** | **I3** | **I4** | **I5** |
|---|---|---|---|---|---|---|---|---|---|---|
| **Iout** | | 1 | | | | | | | | |
| **O6** | | 0.928 | 1 | | | | | | | |
| **O7** | | 0.929 | 0.723 | 1 | | | | | | |
| **Iin** | | 0.855 | 0.794 | 0.793 | 1 | | | | | |
| **I1** | 4.123 | 0.785 | 0.681 | 0.775 | 0.921 | 1 | | | | |
| **I2** | 4.580 | 0.801 | 0.767 | 0.721 | 0.923 | 0.790 | 1 | | | |
| **I3** | 5.368 | 0.705 | 0.647 | 0.661 | 0.888 | 0.788 | 0.811 | 1 | | |
| **I4** | 2.409 | 0.679 | 0.649 | 0.612 | 0.815 | 0.699 | 0.682 | 0.601 | 1 | |
| **I5** | 3.246 | 0.822 | 0.790 | 0.735 | 0.881 | 0.764 | 0.780 | 0.712 | 0.688 | 1 |

Source: Authors.

## 4. Results and discussion

Tables 4 and 5 displays the results of the regressions used to test our hypothesis. Starting with the simple pOLS, we can see that all tests indicates that a FE approach is adequate, together, the F, Breusch-Pagan, and Hausman tests reject the pOLS and RE specifications, in favour of the FE approach. Also, the Welch F test always rejects the null hypothesis that the groups have a common intercept, rendering pOLS inadequate. Regarding the inclusion of time dummies, a Wald joint test rejects the null

hypothesis of no time effects. Both pOLS and FE specifications are reported, however only the results from FE are discussed.

With the first model we intended to test if, in our sample, innovation inputs (Iin) are, in fact, transformed into innovation outputs (Iout) (column 2, table 4). Results show a positive and statistically significant relationship (below the 5% level) between innovation inputs and outputs, thus supporting our Hypothesis H1. This result is also in line with Cornell University et al. (2018).

Table 4: Results of regression models

| **Dependent Variable** | **Iout** | | | |
|---|---|---|---|---|
| **Model** | pOLS | FE | pOLS | FE |
| | (1) | (2) | (3) | (4) |
| **Const.** | -3.508† | | -0.163 | |
| | (1.946) | | (2.343) | |
| **Iin** | 0.866*** | 0.217* | | |
| | (0.045) | (0.108) | | |
| **I1** | | | 0.116* | 0.117† |
| | | | (0.047) | (0.067) |
| **I2** | | | 0.166** | -0.026 |
| | | | (0.054) | (0.041) |
| **I3** | | | 0.166* | -0.039 |
| | | | (0.066) | (0.065) |
| **I4** | | | 0.023 | 0.006 |
| | | | (0.059) | (0.054) |
| **I5** | | | 0.417*** | 0.127* |
| | | | (0.082) | (0.052) |
| **N** | 672 | 672 | 672 | 672 |
| **Adj. $R^2$** | 0.7668 | | 0.7872 | |
| **Within $R^2$** | | 0.3531 | | 0.3716 |
| **Akaike Criterion** | 4 237.199 | 3 346.275 | 4 179.689 | 3 334.763 |
| **Time dummies** | Yes | Yes | Yes | Yes |
| **Wald F (5, 111)** | 36.875*** | 25.418*** | 11.900*** | 10.698*** |
| **Welch F (111, 190)** | | 27.776*** | | 24.392*** |
| **Panel tests:** | | | | |
| **F (111, 554)** | 21.157*** | | | |
| **F (111, 550)** | | | 19.287*** | |
| **Breusch-Pagan** | 933.933*** | | 820.670*** | |
| **Hausman** | 51.022*** | | 67.491*** | |

† p ≤ 0.1; * p ≤ 0.05; ** p ≤ 0.01; *** p ≤ 0.001
Below the coefficients are heteroskedasticity and autocorrelation (HAC) robust standard errors, in parenthesis.

When decomposing the innovation inputs (column 4, table 4), we found a positive and statistically significant relationship (p = 0.0149) between business sophistication (I5) and the output sub-index (Iout). Also, institutions (I1) revealed a positive influence on innovative outputs, although with a weaker statistical significance (p = 0.0834). These finding support Hypothesis H2a and H6a. Surprisingly, we found two of the input pillars to have a negative influence, although without statistical significance, on the total innovative output, namely human capital and research (I2) and infrastructure (I3). In turn, market sophistication (I4) was signed as predicted but did not attain significance. Therefore, results do not support Hypothesis H3a, H4a, and H5a. We now discuss each of these main findings in more detail.

Institutions (I1) show a positive influence on the aggregated innovation output (Hypothesis H2a). This result suggests that countries politically stable, with higher regulatory quality, and with a business enabling environment, provide the necessary foundations for businesses and individuals to innovate. Such arguments are also present in the works of Silve & Plekhanov (2015) and Tebaldi & Elmslie (2013). Business sophistication (I5) is found to have a significant and positive effect on innovation output (Hypothesis H6a). This suggest that the employment of knowledge workers, the quality of linkages between public organizations, universities, and private firms, and the economy's knowledge absorption capacity, are strong inducers of innovation within a country. Similar conclusions can be found in several studies (Bertschek, 1995; Blind & Jungmittag, 2004; Díez-Vial & Montoro-Sánchez, 2016; Liu & Zou, 2008; Love & Mansury, 2007; Maietta, 2015; Sohn et al., 2016). We did not find any significant effect of human capital and research (I2), infrastructure (I3), and market sophistication (I4) (Hypothesis H3a, H4a, and H5a). However, the sign of variables I2 and I3 introduced some questions. Could a measure of input not be translated into outputs? Or, is this a matter of methodological concern? On the one hand, we could argue that investments in innovation enablers (inputs) are not instantaneously transformed into innovative outcomes, with some investments requiring several years to attain the desired outcome, such as the investment in education or public infrastructures. To the limit of the available data, we have additionally tested the same regression including one- and two-year lags on both I2 and I3 variables, obtaining the same negative signs (results are not reported for brevity, but are available upon request). On the other hand, it is also possible that institutionalized habits, such as

corruption, could hamper the transformation of innovation inputs in innovative outputs (Goedhuys, Mohnen, & Taha, 2016).

Table 5 – Results of regression models (continuation)

| **Dependent Variable** | **O6** | | **O7** | |
|---|---|---|---|---|
| **Model** | pOLS | FE | pOLS | FE |
| | (5) | (6) | (7) | (8) |
| **Const.** | -2.929 | | 2.605 | |
| | (3.165) | | (2.768) | |
| **I1** | -0.047 | 0.110 | 0.279*** | 0.125 |
| | (0.074) | (0.066) | (0.057) | (0.110) |
| **I2** | 0.289*** | -0.055 | 0.043 | 0.002 |
| | (0.070) | (0.060) | (0.064) | (0.080) |
| **I3** | 0.069 | -0.091 | 0.262** | 0.013 |
| | (0.084) | (0.074) | (0.081) | (0.095) |
| **I4** | 0.086 | 0.001 | -0.041 | 0.011 |
| | (0.077) | (0.061) | (0.072) | (0.082) |
| **I5** | 0.530*** | 0.192** | 0.304** | 0.063 |
| | (0.089) | (0.064) | (0.107) | (0.077) |
| **N** | 672 | 672 | 672 | 672 |
| **Adj. $R^2$** | 0.7020 | | 0.7081 | |
| **Within $R^2$** | | 0.2612 | | 0.3517 |
| **Akaike Criterion** | 4 501.201 | 3 560.986 | 4 497.234 | 3 874.635 |
| **Time dummies** | Yes | Yes | Yes | Yes |
| **Wald F (5, 111)** | 21.073*** | 17.263*** | 34.095*** | 33.817*** |
| **Welch F (111, 190)** | | 28.779*** | | 21.702*** |
| **Panel tests:** | | | | |
| **F (111, 554)** | | | | |
| **F (111, 550)** | 22.980*** | | 12.458*** | |
| **Breusch-Pagan** | 884.365*** | | 671.117*** | |
| **Hausman** | 69.535*** | | 26.934*** | |

† p ≤ 0.1; * p ≤ 0.05; ** p ≤ 0.01; *** p ≤ 0.001
Below the coefficients are heteroskedasticity and autocorrelation (HAC) robust standard errors, in parenthesis.

Table 5 shows the results of regressing the five input pillars on the two output pillars. When analysing the effects of input pillars on knowledge and technology outputs (O6) (table 5, column 6), we found that only business sophistication has a significant effect (p = 0.0033), with a positive sign, thus supporting Hypothesis H6b. As such, results do not lend support for Hypothesis H2b, H3b, H4b, and H5b. However, we found the same negative effects, again not statistically significant, of human capital and research (I2)

and infrastructure (I3) on knowledge and technology outputs (O6). On column 8 (table 5), none of the innovation input pillars show a statistically significant effect on creative outputs, thus failing to give support for Hypothesis H2c, H3c, H4c, H5c, and H6c.

Regarding the impact of business sophistication on knowledge and technology outputs, the literature suggests that this effect would be expected, since most innovation studies use patent data to proxy for innovation (Bilbao-Osorio & Rodriguez-Pose, 2004; Furman et al., 2002) and this output pillar captures those, as well as other, traditional measures of innovation. Results regarding the effects of input pillars on creative outputs (column 8, table 5) suggest that such pillars are not involved in the formation of creative outputs. These results contradicts those of Sohn et al. (2016), who found direct and indirect relationships between the five input pillars and creative outputs.

### 4.1. Robustness analysis

The above discussion is based on the pooling of all 112 countries together, disregarding substantial differences in the levels of innovation inputs and outputs among them. This could cause the analysis to be biased due to less efficient countries, thus suggesting negative relationships between innovation inputs and outputs. Therefore, following Cruz-Cázares' et al. (2013) argument that efficiency is the best measurement of innovation outcomes, we have applied the same technique to a non-probabilistic sub-sample, composed by the top 20 countries[3] on Innovation Efficiency Index (IEI) (obtained by a simple average for the period of the study). Table 6 shows the results for the sub-sample. In this group of countries, results indicate that a positive and statistically significant relationship between Iin and Iout exist (table 6, column 2), supporting Hypothesis H1. On column 3 (table 6), panel tests indicate that a random effects approach would be preferable, hence, in addition to the FE model (table 6, column 4), we present the results using a RE estimator (table 6, column 5). Both models suggest a significant positive relationship between I1 and Iout, and also between I5 and Iout, thus lending further support to Hypothesis H2a and H6a. Interestingly, when using the RE estimator, all explanatory variables acquire a positive

[3] Armenia, Bulgaria, China, Czech Republic, Estonia, Germany, Hungary, Iceland, Ireland, Israel, Luxemburg, Malta, Moldova, Netherlands, Sweden, Switzerland, Turkey, Ukraine, United Kingdom, and Viet Nam.

sign, which is in line with the proposed hypothesis, however, since I2, I3 and I4 do not attain statistical significance, Hypothesis H3a, H4a, and H5a are not supported.

Table 6 – Results of top 20 countries on IEI

| **Dependent Variable** | | | **Iout** | | |
|---|---|---|---|---|---|
| **Model** | pOLS | FE | pOLS | FE | RE |
| | (1) | (2) | (3) | (4) | (5) |
| **Const.** | 1.718 | | 3.727 | | 6.902† |
| | (3.403) | | (4.509) | | (3.700) |
| **Iin** | 0.861*** | 0.390* | | | |
| | (0.069) | (0.176) | | | |
| **I1** | | | 0.170† | 0.206* | 0.227** |
| | | | (0.088) | (0.093) | (0.073) |
| **I2** | | | 0.098 | 0.017 | 0.080 |
| | | | (0.066) | (0.060) | (0.058) |
| **I3** | | | 0.064 | -0.009 | 0.075 |
| | | | (0.122) | (0.127) | (0.120) |
| **I4** | | | 0.088 | -0.050 | 0.014 |
| | | | (0.094) | (0.069) | (0.057) |
| **I5** | | | 0.427*** | 0.286** | 0.363*** |
| | | | (0.098) | (0.077) | (0.070) |
| **N** | 120 | 120 | 120 | 120 | 120 |
| **Adj. $R^2$** | 0.8475 | | 0.8699 | | |
| **Within $R^2$** | | 0.1487 | | 0.2605 | |
| **Corr (y, ŷ)$^2$** | | | | | 0.8734 |
| **Akaike Criterion** | 664.430 | 561.991 | 649.042 | 553.093 | 659.440 |
| **Time dummies** | Yes | Yes | Yes | Yes | Yes |
| **Wald F (5, 19)** | 6.763*** | 21.052*** | 3.846* | 8.880 | 19.332** |
| **Welch F (19, 37)** | | 10.596*** | | 10.222*** | |
| **Panel tests:** | | | | | |
| **F (19, 94)** | 10.998*** | | | | |
| **F (19, 90)** | | | 9.726*** | | |
| **Breusch-Pagan** | 104.758*** | | 93.626*** | | |
| **Hausman** | 8.607** | | 8.445 | | |

† p ≤ 0.1; * p ≤ 0.05; ** p ≤ 0.01; *** p ≤ 0.001
Below the coefficients are heteroskedasticity and autocorrelation (HAC) robust standard errors, in parenthesis.

Table 7 shows the results of the regressions using the two output pillars as dependent variables. As in the full sample, only business sophistication (I5) present a statistically significant effect (p = 0.0265) on knowledge and technology outputs (O6), with a positive sign (table 7, column 7). Also, apart from I1, all other input pillars present a negative sign. Such results support Hypothesis H6b, while failing to support H2b, H3b, H4b, and H5b. Regarding creative outputs (O7), only institutions (I1) is found to have a significant influence (p = 0.0020), with a positive sign (table 7, column 10). For this specific output, results suggest that market sophistication could have a negative effect.

Table 7 – Results of top 20 countries on IEI (continuation)

| **Dependent Variable** | **O6** | | **O7** | | |
|---|---|---|---|---|---|
| **Model** | pOLS | FE | OLS | FE | RE |
| | (6) | (7) | (8) | (9) | (10) |
| **Const.** | 0.686 | | 6.773 | | 6.164 |
| | (7.064) | | (6.193) | | (7.497) |
| **I1** | -0.167 | 0.114 | 0.507** | 0.297 | 0.423** |
| | (0.158) | (0.252) | (0.136) | (0.255) | (0.137) |
| **I2** | 0.235* | -0.089 | -0.038 | 0.123 | 0.076 |
| | (0.093) | (0.160) | (0.167) | (0.118) | (0.104) |
| **I3** | -0.036 | -0.175 | 0.164 | 0.156 | 0.168 |
| | (0.181) | (0.156) | (0.199) | (0.204) | (0.153) |
| **I4** | 0.278† | -0.139 | -0.102 | 0.039 | -0.015 |
| | (0.141) | (0.145) | (0.182) | (0.109) | (0.097) |
| **I5** | 0.681*** | 0.485* | 0.174 | 0.087 | 0.092 |
| | (0.161) | (0.202) | (0.198) | (0.128) | (0.080) |
| **N** | 120 | 120 | 120 | 120 | 120 |
| **Adj. $R^2$** | 0.7659 | | 0.7082 | | |
| **Within $R^2$** | | 0.2620 | | 0.2724 | |
| **Corr $(y, \hat{y})^2$** | | | | | 0.7188 |
| **Akaike Criterion** | 763.102 | 672.023 | 776.870 | 636.169 | 783.117 |
| **Time dummies** | Yes | Yes | Yes | Yes | Yes |
| **Wald F (5, 19)** | 5.881** | 22.670*** | 5.712** | 32.071*** | 38.177*** |
| **Welch F (19, 37)** | | 6.802*** | | 13.981*** | |
| **Panel tests:** | | | | | |
| **F (19, 90)** | 9.151*** | | 16.264*** | | |
| **Breusch-Pagan** | 65.555*** | | 152.572*** | | |
| **Hausman** | 20.983*** | | 2.312 | | |

† p ≤ 0.1; * p ≤ 0.05; ** p ≤ 0.01; *** p ≤ 0.001

Below the coefficients are heteroskedasticity and autocorrelation (HAC) robust standard errors, in parenthesis.

## 5. Conclusions

With this paper, we intended to shed some light on the relationship between innovation inputs and their resulting outcomes. By using a recognized index developed by major international organizations, which measures the innovation readiness of countries by making the distinction between innovation inputs and outputs, we sought to understand the differentiated effects of each input on each output.

Overall, results indicate a positive link between the aggregated innovation inputs and outputs. However, when disaggregating inputs into five innovation pillars (institutions, human capital and research, infrastructure, market sophistication, and business sophistication), our analysis revealed some surprising findings. Results suggest that human capital and research and infrastructure might have a negative effect on both the aggregated innovation outputs and the knowledge and technology outputs. We take these results with some caution, since the investment in these two pillars is likely to require some years to pay off and the availability of data does not allow lagging those variables for long periods.

A strong positive relationship was found between business sophistication and innovative outputs. This suggest that firms' innovative activities have a major role on the development of innovation outputs. The extent to which firms make use of highly qualified professional, the quality of public/private/academic linkages, and the overall knowledge absorption of a country are key in determining the innovative outcomes of an economy, with a major impact on knowledge and technology outputs. A likely driver of this relationship is the knowledge absorption sub-pillar. The reason for this is that imports of high-tech products and inward FDI enable the development of new and innovative products by domestic firms (Bertschek, 1995; Blind & Jungmittag, 2004; Kim, 2003; Liu & Zou, 2008). Therefore, encouraging domestic firms to seek knowledge outside national borders could yield important innovative outcomes.

Institutions also present a link with innovation outputs. The national environment in which companies operate is likely to influence their innovative activities. Goedhuys et al. (2016) refers to corruption as "grease in the wheels" when institutional obstacles

are encountered, being otherwise an impediment to firm's innovation in sound business environments.

By considering the most efficient countries transforming innovation inputs in outputs, we intended to purge the effect of less efficient countries from the analysis in order to verify the proposed relationships. Nonetheless, results remained essentially the same, suggesting that even the most innovation efficient countries are not able to transform certain inputs into innovative outputs.

### 5.1. Limitations and future research

As with every research, ours has its limitations which ought to be acknowledged. The use of an index could be, in itself, a limitation. Nonetheless, we consider it a solid indicator of national innovativeness, since it blends hard data with experts' opinions on a number of issues. Also, the Global Innovation Index is developed by some of the most important business and economics schools in cooperation with major international organizations. The limited time period available impedes a longer analysis of the influence of certain variables, which we believe could have their impact felt further down the road. A detailed analysis of the business sophistication pillar, all the way to the indicator level, could yield more precise and concluding evidence about its marked effects on innovation outputs.

Lastly, the failure to find positive relationships between every input pillar and innovation outputs lead us to consider that a deeper analysis should be made in order to understand such behaviour, including, but not restricted to, the investigation of direct and indirect relationships between inputs, as suggested by Sohn et al. (2016), while a future analysis with posterior versions of GII could allow for longer lags in pillars related to infrastructure and human capital.

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## 4.3 D3. The Entrepreneurial University and its contextual effects. The role of University Spin-Offs in partially determining the innovation in regions - Antonio Prencipe

*THE ENTREPRENEURIAL UNIVERSITY AND ITS CONTEXTUAL EFFECTS. THE ROLE OF UNIVERSITY SPIN-OFFS IN PARTIALLY DETERMINING THE INNOVATION IN REGIONS*

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ABSTRACT

The technology and knowledge transfer from University to industry has raised the attention of policy makers and practitioners as fundamental process in promoting the development of regional innovation and entrepreneurship. University Spin-Offs (USOs), firms established to commercialize the knowledge and technology outcomes of academic research, may constitutes an effective mechanism to improve the innovative dynamics in the regional area. The paper explores the assumption that USOs may partially determine the innovation of regions they are located. From a panel sample of 944 USOs placed in 20 Italian administrative regions, the findings remark that USOs (analysed as [1] number of USOs from each University and [2] patents activity of USOs) actually has a positive impact on the regional innovation in term of regional patent applications, while a weak role of USOs seems to emerge in term of regional expenditure in R&D.
*Keywords:* University Spin-Offs; regional innovation; Entrepreneurial University; Italy.

*Clasificación JEL:* O30, O32.

Scientific area according to the congress list: 1. Innovation and technological development in the world economy

Is it candidate to the **José Luís Sampedro Prize/Award**? Yes__ No ✖_

## 1. INTRODUCTION

In view of the widespread expansion that the phenomenon continues to show in Europe, University Spin-Offs (USOs) are considered one of the most qualified entrepreneurial initiatives in offering effective and profitable ways for the diffusion of new technologies and knowledge (Mathisen and Rasmussen, 2019; Miranda, et al., 2018; Fini et al., 2017; Lazzeri and Piccaluga, 2012); as well as they are commonly included among the most active and recommended tools to stimulate the creation and development of knowledge-based economies (Benneworth and Charles, 2005; Sternberg, 2014). As a result of the numerical and dimensional development of these types of businesses, the clarification of the determinants regarding their growth and effects has been definitively integrated into the policy agenda dedicated to the dissemination and promotion of innovation in definite environmental contexts (Chiesa and Piccaluga, 2000; Siegel, 2018).

In line with the emerging configuration outlined, several studies (Kennedy and Patton, 2011; Iacobucci and Micozzi, 2015; Etzkowitz and Ranga, 2015) have emphasized that the creation and dissemination of knowledge by universities should be included among the most significant driving forces for the technological innovation of an economy, both at local and at national scale (Mueller et al., 2006). Indeed, the declination on the regional dimension of the perspective advanced by the Knowledge Spillover Theory of Entrepreneurship (Audretsch and Lehmann, 2005) suggests that the actual spillover of knowledge and innovation in the local socio-economic environment is strictly dependent on the regional entrepreneurship capital (Guerrero and Urbano, 2012.; Audretsch et al., 2008), as well as on the efforts and innovative capacity of local agents: factors that discriminate not only the aptitude of selecting the best business projects, but also the possibility to allocate adequate resources (Friedman and Silberman, 2003).

Similarly, it seems reasonable that geographic proximity of a University and their entrepreneurial actors (such as USOs) to a knowledge and technology intensive industry can be certainly a source of relevant knowledge and technological externalities. Indeed, USOs may constitutes a key mean for disseminating the newest knowledge and technologies from University to the local entrepreneurial context (Sternberg 2014; Campbell and Carayannis 2016). This follow closely the argument advocated by the theory of endogenous economic growth, for which growth and innovation have been partially related to the local academia by transferring technologies into developed innovations. Furthermore, as being possible sources of forthcoming knowledge and technologies transfers, they implicitly foster local economic development and innovation by attracting innovative firms to the local context (Funke and Niebuhr, 2005; Varga, 1999).

However, although their importance, the above arguments are not fully explored in the literature of University entrepreneurship, leaving open some noteworthy knowledge gaps. Indeed, up to now, there are few studies that are directly dedicated in studying the effect of USOs on the local context. An efforts in this sense has been made by the study of Iacobbuci and Micozzi (2015), which investigated the direct (such as the number of spin-offs and their size in terms of sales and employees, the number of entrepreneurs involved) and indirect effects (such as the ability to form new networks to access finance and to improve sales and R&D partnerships) of academic spin-offs on the local context in Italy. Also, Vincett (2010) analysed the economic impacts of academic spin-offs by estimating the lifetime effects of academic spin-off and compare the effects with all public direct and indirect funding. Nevertheless, the existing literature seems not to cover the potential technology and knowledge transfer effects of USOs in improving the

innovation capabilities and outcomes of the local context. In this paper, we want to fill this gap by investigating whether USOs partially determine the innovation of regions. Additionally, the spin-off phenomenon in different European regions is likely to diverge from that one observed in successful high-tech clusters as Silicon Valley and Route 128 in the United Stated. Hence, this call to increase the evaluation of USOs impact to the local context in European regions.
This paper purposes to add some new evidences in this regard. To this end, the paper analyses a panel sample of 944 USOs located in 20 Italian administrative regions. Italy is one of the key European countries exposing a constant development of the USO phenomenon (Fini et al., 2011; Meoli and Vismara, 2016). Indeed, consistent with the last Netval report (Netval, 2018), at 31.12.2017 there are 1.373 research spinoffs in Italy.
The paper aims to offer a prospective contribution to the knowledge – both theoretical and practical - about the role of the Entrepreneurial University, by means of USOs, in partially determine the innovation of local contexts thanks to the proactive role of knowledge and technology transfer. Also, the paper aims to boost appropriate policy actions dedicated to rise the regional development, contributing to the effective exploitation of innovation and promoting the socio-economic growth of the local areas.

## 2. THEORETICAL BACKGROUND

### 2.1. THE UNIVERSITY KNOWLEDGE AND TECHNOLOGY' EFFECT ON THE LOCAL CONTEXT

The role of universities with their knowledge impacts are considered critical externalities of academic institutions on a local context (Florax and Folmer, 1992; Bleaney et al., 1992). Although the approaches of University' impacts do not diverge basically from the comparable outcomes of any others impact produced by public local institutions, the University knowledge effect is related to the specific mechanisms for which universities can impact on the socio-economic settings of a local area (Siegfried et al., 2007; Pellenbarg, 2005).
In particular, knowledge effects are enabled through the so-called University technology transfers, which represents a potential and powerful direct outcome of the academic institution on the local economy. Namely, valuable ides from a technological point of view created in academic laboratories are transferred into innovative products or new production processes.
Further, an indirect effect of technology transfer emerges on regional socio-economic growth. Indeed, the entrepreneurial organizations may locate in the local area to take benefit of novel, economically valuable technologies created in academia. It is to note that University technology transfer is any practice by which basic R&D researches, knowledge and inventions transfer from an academic institution to the industry (Bania et al., 1992; Acs et al., 1999). The technology and knowledge may be moved from the universities throughout several mechanisms, such as collaboration in R&D between University and industry, academic seminars, academic journal publications, business incubators, science parks, technology licensing and USO to commercialize valuable research' outcome and knowledge/technology developed at the academic institution (Lundberg, 2017).

### 2.1. THE IMPACT OF USOS ON THE INNOVATION OF REGIONS

In the current University model of the Triple Helix, the academic institution is called to take a leading role in the promotion and creation of innovation, inserting itself among the first proponents of the process aimed at disseminating innovation in the current

knowledge-based society (Etzkowitz and Leydesdorff, 2017; Etzkowitz and Ranga, 2015). The progressive enrichment of the University' as a generator of opportunities for innovative forms of entrepreneurship - Entrepreneurial University - has changed the socio-economic role of universities in many countries (Etzkowitz, 2004). On the other hand, the theoretical analysis and the experimental investigation about the mechanisms for which the University can fulfil the new task converge in signalling the creation of spin-off companies, a powerful tool for the commercialization of knowledge and technologies developed in the field of Higher Education (Wright, 2007; O'shea et al., 2005). Indeed, these types of firms provide a direct and leading contribution to the development of the socio-economic environment, especially in terms of innovative contribution (Perkmann et al., 2013; Martinelli et al., 2008). This statement is likely bearing in mind that a greater entrepreneurial orientation of the University could facilitate the absorption of the knowledge and technologies developed in the academia by the firms operating in the regional context, with a consequent attribution of economic-social value to the one that to the others (Di Gregorio and Shane, 2003; Lockett and Wright, 2005; Guerrero et al., 2015).

Emphasizing the impact of University research on the skills and innovation processes developed by firms (Audretsch et al., 2012; Leten et al., 2011; Johnstonm and Huggins, 2017), some studies have found that the USOs can effectively produce a spill-over of knowledge towards the business world. Nonetheless, this type of event tends to manifest itself as very localized and appears strongly bound to the requirement of geographical proximity between the University and the business environments. In the Italian context and in the context of the interaction between university and local industry, some problems emerge which strictly undermine the effectiveness of the transfer of knowledge, skills and technologies from research to entrepreneurship (Cardamone et al., 2015). The obstacles to this effort are primarily recognizable in a cultural environment poorly inclined to relationship and collaboration between academicians and entrepreneurs, with a lack of networks rooted and widespread between universities and industry (Link and Scott, 2005; Berbegal-Mirabent et al., 2015). In view of this emerging setting, it becomes critical to enhance the role of liaison fulfilled by USOs. These by acting as intermediaries for the dissemination of knowledge/technology generated by the University to potential users, such as companies and institutions (Cardamone et al., 2015; Bramwell and Wolfe, 2008), constitute a pool of qualified resources both for the effective economic development of regional context. Additionally, USOs have a part in updating the industrial production from traditional or low-tech sectors to high-tech sectors, as well as contributing to the transition towards the modern knowledge society (Rodríguez-Gulías et al., 2016). The development of innovation and diffusion of knowledge/technological know-how by USOs is also remarked by the Knowledge Spillover Theory of Entrepreneurship, an approach that explain the need to create new companies for the declination in economic term of knowledge/technology developed through University research (Carree et al., 2014; Audretsch and Lehmann, 2005).

According to the evidence emerging from previous empirical studies, a more intense and effective interaction between the University and the local industry - through USOs - positively influences the results achieved by both actors, both in terms of technology transfer (O'Shea et al., 2005; Landry et al., 2006), both in terms of economic/innovative performance (Acs and Plummer, 2005). In the theoretical literature, however, the impact produced by the activity of USOs on the regional socio-economic environment has received evaluations and findings that are often premature and almost only partial (Vincett, 2010; Berggren and Lindholm-Dahlstrand, 2009; Benneworth and Charles, 2005). However, it is possible to rely on the classification proposed by Iacobucci and Micozzi (2015) and analyse the influence that USOs are potentially able to exert on regional socio-economic systems based on the following factors:

- number of active spin-offs;
- performance in terms of growth achieved by them;
- type and intensity of positive externalities produced on the local system.

In addition to the measurement criteria described above - associated with those that are generally defined as "direct" effects - it arises the role USOs play in the technological promotion and, therefore, in the emergence of new technology-driven clusters, although this constitutes an "indirect" effect only (Smith and Ho, 2006; Di Gregorio and Shane, 2003). This evidence is particularly true with regard to socio-economic areas characterized by underdeveloped and not well-diffused innovation (Berggren and Lindholm-Dahlstrand, 2009), such as the Italian context and several European countries (mainly in the Mediterranean area).

In addition to the above arguments, it should be noted that USOs are knowledge-based firms and, generally, they are established by the University through patents and other forms of intellectual property (Lockett and Wright, 2005). The innovative potential of these types of firms, therefore, also depends on the possibility to commercialize the developed technology, guaranteed by the filing of patents (Munari et al., 2014). The latter, by providing protection and ensuring the economic appropriation of the invention advanced, are effective means to facilitate and optimize the diffusion of new knowledge and technologies within the socio-economic context of reference and, consequently, they can be validly enclosed among the most rational criteria to transfer the innovation to the local industry, partially determining the latent impact of USO's on the innovation of the regional context (Woo et al., 2015).

*Research hypothesis*: USOs have a positive effect in partially determining the innovation of regions where they are located.

## 3. METHOD

### 3.1. SAMPLE AND DATA

In order to empirically validate the defined research hypothesis, information about USOs was collected from Netval database, which is incorporated in the project "Spin-off Italia" and founded in association with Netval, Università Politecnica delle Marche (Polytechnic University of Marche) and Scuola Superiore Sant'Anna – Istituto di Management (Saint Anna's Upper School – Management Institute). The Netval database comprises rationalized data about the full population of active spin-off firms in Italy. From the complete database, we collected only the USOs, i.e. 1,275 firms. Furthermore, additional data about the selected firms was gathered from Aida BdV database. The Aida BdV database is an Italian subsection of ORBIS database, which contains financial, biographical and merchandise historical data of about 700,000 Italian active firms. Precisely, financial data are offered by Honyvem, which gets and recovers all formal financial records placed in the Italian Chambers of Commerce. From the 1,275 USOs we omitted those firms for which information were not accessible in Aida BdV database for the time period selected. Thus, the final panel sample contains 944 Italian USOs, covering a period from 2005 to 2014.

Data about the regional innovation of the all-20 Italian administrative regions (i.e. Valle d'Aosta, Trentino-Alto Adige, Lombardy, Veneto, Emilia-Romagna, Marche, Abruzzi, Molise, Apulia, Calabria, Sardinia, Piedmont, Friuli-Venezia Giulia, Liguria, Tuscany, Umbria, Lazio, Campania, Basilicata, Sicily) was gathered by obtaining information from the records collected by the Organization for Economic Co-operation and Development (OECD). In addition, information concerning the regional Venture Capital & Private Equity industry was collected from the yearly statements of Private Equity Monitor - PEM®.

### 3.2. VARIABLE DEFINITION

#### 3.2.1. DEPENDENT VARIABLES

With the aim to measure the innovation of Italian administrative regions we used two variables. First, we used the number of patent applications from the analysed regions (REGION PATENT). Indeed, the literature claims that patents offer a consistent measure of the innovative spillover of a region (innovation output), embodying a fundamental and dominant proxy of regional creation of knowledge and technology (Acs et al., 2002).
Second, we used the total volume of regional expenditure in R&D (REGION R&D), which is argued to be a key measure of regional innovation (Link and Siegel 2005), constituting an important innovation input.

#### 3.2.2. INDEPENDENT VARIABLE

In order to predict the latent impact of USOs on the innovation of regions, it was used the number (count) of USOs from each University (NUMBER USO). Indeed, the count of USOs is a proper measure to assess the impact of spill-over effect on regional environment (Iacobuzzi and Micozzi 2015). Also, a dummy variable about the patent activity (number of patents on each year) of USOs has been used (USO PATENT). Of course, patents are key results of firms' innovation, embodying an entrepreneurial outcome within the innovative actions of the University' firms. Furthermore, patenting activity is applied usually to assess the innovation outcome of USOs (Rodríguez-Gulías et al. 2016).

#### 3.2.3. CONTROL VARIABLES

First, we controlled for one of the key inputs in developing regional innovation, i.e. the human capitals in R&D activities, which should have a relation with regional patents. For this variable it was used the amount of R&D workers in the region over total amount of workers (R&D HUMAN CAPITAL).
Second, since the innovation of regions is related to the knowledge aptitudes and know-how of the individuals existing in the local area, it was used the ratio of adult people (age 16+) with higher education in each region (HIGH EDUC).
Third, we controlled for the extent of Venture Capital (VC) and Private Equity (PE) industry by means of the total amount of early agreements for VC and PE in each region (VC/PE).
Fourth, we controlled for the natural logarithm of the amount of innovative companies in each region (INNOV FIRMS). Finally, we controlled for the pro-capite GDP in each region (GDP).

## 4. RESULTS

### 4.1. DESCRIPTIVE STATISTICS

Table 1 shows the descriptive statistics of variables used in the study. Concerning the first measure of regional innovation used - the amount of patent applications (innovation output) - the sample shows an average of 414.88 patents, with a medium-high heterogeneity in the sample (S.D. = 408.43). This result remarks a good distribution of

the innovative outputs in the Italian regions, though its extent varies considerably between regions. The second measure of regional innovation used - the total amount of regional expenditure in R&D (innovation input) - shows an average in the sample of 1,591.64€, while the dispersion in the sample is quite high (S.D. = 1,281.37).
The descriptive statistics suggest that it occurs a relevant heterogeneity in the analysed Italian regions in term of innovation, advocating that the regional areas are reasonably diversified in Italy.
Regarding to the first fundamental explanatory variable, the amount of USOs from each University, the sample reveals an average of about 28 USOs per academic institution. However, the amount of USOs is affected by a medium-high dispersion in the sample (S.D. = 16.07). The result suggests that USO is a disseminated phenomenon in the Italian context, with a relevant latent influence on the regional area in which it is placed, although this distribution considerably varies between regions. This may generate concerns also with regard to the effect' power of USOs on the regional innovation, rising differences in innovation efforts between regions.
Additionally, about the second main explanatory variable, the patenting activity of USOs, the sample denotes an average of 4% of USOs with patents. This result remarks the small orientation to innovative by the analysed USOs. However, the evidence could suggest only a small aptitude to protect the innovation produced rather an underperformance in innovation outcomes.

TABLE 1: DESCRIPTIVE STATISTICS

| | **Obs.** | **Mean** | **Std. Dev.** | **Min.** | **Max.** |
|---|---|---|---|---|---|
| REGION PATENT | 7,552 | 414.8825 | 408.4335 | 0.3500 | 1509.0500 |
| REGION R&D | 8,496 | 1,591.6440 | 1,281.3710 | 12 | 4,625.4520 |
| NUMBER USO | 9,440 | 27.7341 | 16.0609 | 1 | 70 |
| USO PATENT | 9,440 | 0.0414 | 0.1992 | 0 | 1 |
| R&D HUMAN CAPITAL | 7,539 | 6.1062 | 15.7358 | 0.5400 | 112.2400 |
| HIGH EDUC | 9,440 | 17.0699 | 2.9603 | 11.1000 | 36.1000 |
| VC/PE | 9,440 | 116.0561 | 138.3637 | 0 | 464 |
| INNOV FIRMS | 9,440 | 8.4822 | 0.9382 | 4.6821 | 9.9512 |
| GDP | 9,440 | 27,783.2900 | 5,728.0110 | 15,800 | 37,250 |

Source: Author's own elaboration.

Furthermore, the lack of high significant correlations among the key explicative variables (Table 2) suggests that multicollinearity is not a main concern in this study.

TABLE 2: CORRELATIONS

| | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | REGION PATENT | 1.0000 | | | | | | | | |
| 2 | REGION R&D | 0.8356* | 1.0000 | | | | | | | |
| 3 | NUMBER USO | 0.1039* | 0.0662* | 1.0000 | | | | | | |
| 4 | USO PATENT | 0.0514* | 0.0515* | 0.0216* | 1.0000 | | | | | |
| 5 | R&D HUMAN CAPITAL | 0.1611* | 0.0205 | 0.0279* | -0.0368* | 1.0000 | | | | |
| 6 | HIGH EDUC | -0.1306* | 0.1376* | -0.1813* | 0.0114 | -0.2657* | 1.0000 | | | |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| 7 | INNOV FIRMS | 0.8323* | 0.8261* | 0.1481* | 0.0559* | 0.1200* | -0.0782* | 1.0000 | | |
| 8 | VC/PE | 0.9586* | 0.8697* | 0.0034 | 0.0587* | 0.0922* | -0.0249* | 0.7813* | 1.0000 | |
| 9 | GDP | 0.6760* | 0.6799* | 0.1435* | 0.0328* | 0.0294* | 0.3765* | 0.6354* | 0.6502* | 1.0000 |

Source: Author's own elaboration.

### 4.2. ESTIMATION OF THE DEFINED REGRESSION MODELS

Table 3 reports the results of the Model (1) and Model (2) with the aim to evaluate the effect of USOs, in term of amount (count) of USOs from each University, on regional innovation.

In the Model (1), which predicts the effect of the number of USOs from a given University on the amount of patent applications at regional level, the estimated coefficient on the variable NUMBER USO is positive and statistically significant (column ii, coeff. = 0.5476, $p< 0.001$). In the Model (2), which predicts the effect of the number of USOs from a given University on the regional expenditure in R&D, the estimated coefficient on the variable NUMBER USO is positive but not statistically significant.

These evidences provide partially support to the defined research hypothesis, suggesting that the presence of USOs contribute to determine the innovation of regions in which they are placed only in term of innovation output, but not in term of innovation input.

TABLE 3: ESTIMATION OF THE DEFINED REGRESSION MODELS PREDICTING THE EFFECT OF USOS, IN TERM OF AMOUNT (COUNT) OF USOS FROM EACH UNIVERSITY, ON REGIONAL INNOVATION.

| Dependent variable: | Model 1<br>REGION PATENT | | Model 2<br>REGION R&D | |
|---|---|---|---|---|
| | (i) | (ii) | (iii) | (iv) |
| Main effect | | | | |
| NUMBER USO | | 0.5476*** | | 1.6506 |
| | | (0.1028) | | (1.2797) |
| Control variables | | | | |
| R&D HUMAN CAPITAL | 0.5329*** | 0.5547*** | -3.5817*** | -3.5848*** |
| | (0.0536) | (0.0533) | (0.2457) | (0.2459) |
| HIGH EDUC | -25.5163*** | -24.6635*** | 61.9847*** | 62.0698*** |
| | (1.1976) | (1.2281) | (3.0023) | (2.9953) |
| INNOV FIRMS | 51.2184*** | 49.2491*** | 496.9692*** | 487.0723*** |
| | (4.1011) | (4.3458) | (30.1672) | (31.2164) |
| VC/PE | 2.0823*** | 2.1087*** | 4.7924*** | 4.8525*** |
| | (0.0210) | (0.0228) | (0.1698) | (0.1878) |
| GDP | 0.01459*** | 0.0140*** | 0.0216*** | 0.0213*** |
| | (0.0005) | (0.0006) | (0.0031) | (0.0031) |
| Number of obs | 6,595 | 6,595 | 7,539 | 7,539 |
| R-sq: | | | | |
| within | 0.2563 | 0.2557 | 0.4896 | 0.4895 |

| | | | | |
|---|---|---|---|---|
| between | 0.9825 | 0.9832 | 0.8456 | 0.8461 |
| overall | 0.9590 | 0.9596 | 0.8377 | 0.8382 |
| Wald $chi^2(6)$ | 271549.0400*** | 265344.8200*** | 33463.4400*** | 34038.9200*** |

Source: Author's own elaboration.

Table 4 reports the results of the Model (3) and Model (4) with the aim to evaluate the effect of USOs, in term of patent activity, on regional innovation. In the Model (3), which predicts the effect of the USOs' patents on the number of patent applications in the regions, the estimated coefficient on the variable USO PATENT is positive and statistically significant (column ii, coeff. = 8.7066, $p< 0.001$). In the Model (4), which predicts the effect of the USOs' patents on the regional expenditure in R&D, the estimated coefficient on the variable USO PATENT is positive but not statistically significant.

The results from the estimated models suggest that the innovation outcome of USOs partially contribute to determine the innovation of regions in which they are placed. Indeed, also in this case, the evidences remark that USOs' patents have a superior impact on innovation output rather than on innovation input at regional level. Hence, in general the results partially support the defined research hypothesis.

TABLE 4: ESTIMATION OF THE DEFINED REGRESSION MODELS PREDICTING THE EFFECT OF USOS, IN TERM OF PATENT ACTIVITY, ON REGIONAL INNOVATION.

| Dependent variable: | Model 3 REGION PATENT | | Model 4 REGION R&D | |
|---|---|---|---|---|
| | (i) | (ii) | (iii) | (iv) |
| Main effect | | | | |
| USO PATENT | | 8.7066* | | 8.0431 |
| | | (4.4493) | | (9.7719) |
| Control variables | | | | |
| R&D HUMAN CAPITAL | 0.5329*** | 0.5368*** | -3.5817*** | -3.5787*** |
| | (0.0536) | (0.0537) | (0.2457) | (0.2459) |
| HIGH EDUC | -25.5163*** | -25.5297*** | 61.9847*** | 61.9667*** |
| | (1.1976) | (1.1973) | (3.0023) | (3.0018) |
| INNOV FIRMS | 51.2184*** | 51.1767*** | 496.9692*** | 496.9356*** |
| | (4.1011) | (4.1017) | (30.1672) | (30.1733) |
| VC/PE | 2.0823*** | 2.0817*** | 4.7924*** | 4.7919*** |
| | (0.0210) | (0.0210) | (0.1698) | (0.1699) |
| GDP | 0.01459*** | 0.0146*** | 0.0216*** | 0.0216*** |
| | (0.0005) | (0.0005) | (0.0031) | (0.0031) |
| Number of obs | 6,595 | 6,595 | 7,539 | 7,539 |
| R-sq: | | | | |
| within | 0.2563 | 0.2565 | 0.4896 | 0.4897 |
| between | 0.9825 | 0.9826 | 0.8456 | 0.8456 |
| overall | 0.9590 | 0.9591 | 0.8377 | 0.8377 |
| Wald $chi^2(6)$ | 271549.0400*** | 270703.5200*** | 33463.4400*** | 33474.8700*** |

Source: Author's own elaboration.

## 5. CONCLUSIONS

The paper aimed to analyse the effect of USOs in partially determine the innovation of regional contexts in which they are placed. This study provides new insights, although only partial, about the understanding of the dynamics affecting innovativeness in the regions. The findings from a panel sample of 944 Italian USOs

placed in 20 Italian administrative regions remark the positive effect of USOs, both in term of amount (count) of USOs from each academic institution and in term USOs' patents activity, on the level of regional innovation measured as amount of patent applications at regional level.
These evidences suggest that knowledge and technologies transfer from the University by USOs may produce a relevant impact in the regional area, rising its innovative capabilities especially in term of innovation output, i.e. patents, operating as key intermediate in the innovative advance of regions.
Nevertheless, concerning the effect of USOs, both in term of amount (count) of USOs from a each academic institution and in term USOs' patents activity, on the regional expenditure in R&D, the findings remark a weak effect of USOs in determine the basic regional elements of innovation, i.e. their innovation input measured by the R&D efforts at regional level. Though the innovation outcome of the university ventures provides greater benefits to the local area (which stems from the knowledge/technology generated in academia), they will be yet inadequate to rise the innovation input of the regions. This result remarks that the impact of USOs to the innovation of regions, although considerably, is yet not-fully exploited. Indeed, the regional setting will take advantage from the innovative output and entrepreneurial activity of USOs, which conversely forms the input to improve the basic elements in the regional context that raise the innovation efforts of the same, both in term of innovation inputs and, then, translating them in innovation outputs (consistently with the Knowledge Spillover Theory of Entrepreneurship). However, the emerging findings from our sample seems to reveal that the Italian USOs have not advanced an appropriate level of innovative and entrepreneurial activity to aid the regional area in the development of the fundamental milieu for the exploitation of its innovative copiabilities. On the other hand, the lowest impact of USOs on innovation input of regions may be related to the weak capability of the socio-economic areas to capture and exploit the knowledge and technology spillover from USOs.
However, generally USOs seems to affect the innovation of regions in Italy, although their effects are only partial and not-fully integrated in the knowledge and technology spillover process.
The paper provides suitable theoretical and managerial/policy implications. From a theoretical point of view, the study provides news insights in the literature about the function of knowledge and technology transfer process from the academia in rise the innovation efforts of local areas. Chiefly, the paper contributes in supporting he theoretical arguments associated to the valuable innovative effect and potential knowledge spillovers from University. In this regard, the study confirms the effective role, although partial, of USOs in stimulating a confident background for the rise of innovation in regions where they are placed.
From a managerial/policy point of view, the emerging role of USOs in partially determine the innovation of regions calls policy makers to develop action and dedicated programs to improve strong and mutual partnership among every part of the local area involved in the knowledge/technology spillover process, from the University to the industry. This is especially important for that regions missing a strong innovative and entrepreneurial ecosystem (the regions of the South for the Italian context) that demand a resilient and integrated agenda to increase their innovative potentials and knowledge/technology exploitation of their University and industry. In this regard, a possible and rational recommendation for policy makers and practitioners is to employ a more selective approach in the supporting programs, rather the traditional and well-diffused bottom up approach, aimed at boosting the

most effective and promising USOs in a definite technological and knowledge domain.

Nevertheless, the paper is not free from limitations, which leaves room for future research. The empirical study is based only on some determinants of innovation of the local area and only on some impacts exerted by USOs. Moreover, the models developed can be considered only as basic cognitive elements to help the improvement of the existing knowledge about the effects of USOs in regions they are located, as well as serving as inputs for a more system conceptual and empirical model on the topic. Further studies may include additional variables measuring regional innovation through proxies expressing the existence of high-tech start-ups and new technology-based firms (NTBF) in the local area – which constitute basic agents in the generation of on innovation-based links between University and industry - as well as Science Parks and technology clusters.

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# 5 Challenges and Opportunities of Innovation

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## 5.1 E1. Challenges and opportunities of smart specialization strategies: the regional innovation system of the state of Mexico - José Luis Solleiro-Rebolledo, Rosario Castañón –Ibarra, Laura Martínez-Salvador

***CHALLENGES AND OPPORTUNITIES OF SMART SPECIALIZATION STRATEGIES: THE REGIONAL INNOVATION SYSTEM OF THE STATE OF MEXICO, MEXICO***

***RETOS Y OPORTUNIDADES DE LAS ESTRATEGIAS DE ESPECIALIZACIÓN INTELIGENTE: EL SISTEMA REGIONAL DE INNOVACIÓN DEL ESTADO DE MÉXICO, MÉXICO***

***DESAFIOS E OPORTUNIDADES DAS ESTRATÉGIAS DE ESPECIALIZAÇÃO INTELIGENTE: O SISTEMA DE INOVAÇÃO REGIONAL DO ESTADO DO MÉXICO, MÉXICO***

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**ABSTRACT**

Research and Innovation Strategies for Smart Specialization (RIS3) focuses on identifying the competitive potential of the regions. In Mexico RIS3 has been implemented to define state innovation agendas (SIA), which results in a series of regional innovation projects defined by triple helix actors.
In this paper we analyze the experience of applying RIS3 methodology to identify smart specialization areas for the most populated state in the country as the base to structure a regional innovation system (RIS) that has the potential to improve competitiveness and scioeconomic conditions in that region.
This is a case study in which participatory research methods were applied, mainly because authors of this paper played an important role on the structuring of the RIS and the implementation of the SIA for priority sectors. It is important to analyze these experiences in order to identify challenges and opportunities that may appear during RIS implementation in developing countries.

**Keywords**: Regional innovation system, smart specialization, innovation.
**JEL Classification**: O330

**RESUMEN**

El enfoque analítico del Research and Innovation Strategies for Smart Specialisation (RIS3), se enfoca en identificar el potencial competitivo de las regiones. En México esta estrategia se ha implementado para definir agendas estatales de innovación (AEI), dando como resultado una serie de proyectos de innovación regional definidos por actores de la triple hélice.
El presente documento tiene como objetivo analizar la aplicación de la metodología RIS3 en la definición de áreas de especialización inteligente como base para la estructuración del sistema regional de innovación (SRI) del Estado de México en México, una de las regiones con mayor importancia económica, social y política en el país.
La metodología utilizada se basó en la investigación- acción participativa dada la participación de los autores en la implementación del SRI y de la AEI. Es importante analizar estas experiencias a fin de identificar los factores claves, retos y oportunidades en los procesos de implementación de estas estrategias en países en desarrollo.

**Palabras clave:** Sistema regional de innovación, especialización inteligente, innovación.
**Clasificación JEL:** O330

**RESUMO**

A abordagem analítica das Estratégias de Pesquisa e Inovação para Especialização Inteligente (RIS3) concentra-se em identificar o potencial competitivo das regiões. No México, essa estratégia foi implementada para definir as agendas de inovação estaduais (AIE), resultando numa série de projetos regionais de inovação definidos pelos atores da tripla hélice.
O objetivo deste documento é analisar a aplicação da metodologia RIS3 na definição de áreas de especialização inteligente como base para a estruturação do sistema de inovação regional (SIR) do Estado do México no México, uma das regiões economicamente mais importantes social e política no país.
A metodologia utilizada baseou-se na pesquisa-ação participativa, dada a participação dos autores na implementação do SIR e do AIE. É importante analisar essas experiências para identificar os principais fatores, desafios e oportunidades nos processos de implementação dessas estratégias nos países em desenvolvimento.

**Palavras-chave:** Sistema regional de inovação, especialização inteligente, inovação.
**Classificação JEL:** O330

Scientific area according to the congress list:

1. **Innovación y desarrollo tecnológico en la economía mundial**

Is it candidate to the José Luís Sampedro Prize/Award? Yes __ No _X_

## 1. INTRODUCCIÓN

En la actualidad la innovación, como ancla de arrastre de la competitividad y el desarrollo de las regiones, es una premisa ampliamente aceptadas por agencias económicas, instituciones público-privadas, *policy makers* y demás actores productivos. Esta innovación, al no ser un hecho aislado, contempla la inclusión de relaciones en sus procesos y en su desarrollo, así como esquemas de negociación, coordinación e intercambio de conocimiento.

En este sentido, una serie de intercambios se dan entre el conjunto de actores que, en la dinámica productiva, tienen injerencia y participación directa en el proceso creador de innovaciones (Rózga & Solleiro, 2017) y conforman un Sistema Nacional de Innovación (SNI). Sin embargo, las escalas en los procesos de innovación impulsan el estudio de nuevas dimensiones para la definición de las condiciones necesarias y suficientes para generar procesos de innovación y competitividad; estas nuevas dimensiones se abordan en el estudio de los Sistemas Regionales de Innovación (SRI).

El enfoque analítico del Research and Innovation Strategies for Smart Specialisation (RIS3), desarrollado por la Unión Europea en 2013, se enfoca en identificar el potencial competitivo de las regiones. Es de mencionar que, en México desde 2014, esta estrategia se ha implementado para definir agendas estatales de innovación (AEI)[1], dando como resultado una serie de proyectos de innovación regional definidos por actores de la triple hélice.

Considerando estas experiencias, el presente documento tiene como objetivo principal analizar la aplicación de la metodología RIS3 en la definición de áreas de especialización inteligente como base para la estructuración del SRI e implementación de la AEI del Estado de México, una de las regiones con mayor importancia económica, social y política en el país. Lo anterior recalcando los retos y oportunidades que la aplicación de este enfoque ha traído consigo.

Los primeros apartados de este documento permiten identificar el entramado teórico que ha dado paso a la importancia de la regionalización en los procesos de

[1] Es importante destacar que una agenda estatal de innovación es un listado de temas estratégicos y prioritarios que habrán de recibir tratamiento y proceso secuencial de consolidación del sistema. Estas agendas de innovación se convierten en instrumentos de política pública para coordinar actores del sistema.

innovación. De igual forma, se destacan los elementos teóricos y metodológicos que componen la estrategia de especialización inteligente RIS3.

Posteriormente, se detalla el proceso de estructuración del SRI y la implementación de la AEI en el Estado de México, puntualizando las acciones de gobernanza. Después, se desarrolla una discusión en torno a los retos y áreas de oportunidad que se presentaron durante la aplicación de la metodología RIS3 en este caso de estudio. Breves conclusiones dan término al presente documento.

## 2. REVISIÓN DE LA LITERATURA

A finales de los años ochentas, la regionalización de la innovación comenzó a tomar importancia en muchos países debido a la relevancia que los territorios han tenido en la generación de innovaciones. Estos territorios se convierten en espacios que incentivan la acumulación de conocimiento y la interacción entre agentes al interior de las regiones. Considerando lo anterior, se han definido modelos territoriales de innovación tales como los Sistemas Regionales de Innovación (SRI), en el cual convergen como agentes demandantes y oferentes de tecnología, las organizaciones de transferencia tecnológica; infraestructura tecnológica y de innovación y aparatos de financiamiento (Komninos, 2002). Este enfoque considera la flexibilidad del concepto mismo de Sistema Nacional de Innovación (Lundvall, 1992) a fin de incluir microsistemas de innovación a diferentes escalas (Rózga & Solleiro, 2017).

Con el objetivo de impulsar la innovación en las regiones, surgen enfoques como el de *Research and Innovation Strategies for Smart Specialisation* (RIS3), desarrollado por la Unión Europea en 2013, bajo la premisa de que las estrategias de innovación deben ser construidas desde las fortalezas, capacidades y conocimiento endógeno de cada una de las regiones. Esta metodología, consiste en una serie de principios contenidos en una agenda bajo un enfoque integral, localizado y orientado hacia la transformación económica. El enfoque central es que “cada región debe seleccionar un número limitado de áreas de actividad o de conocimiento en las que la región puede ser realmente competitiva en el marco de una economía cada vez más globalizada” (Del Castilli & Paton, 2013 p. 17).

El diseño de la RIS3 está basado en el modelo de especialización inteligente (EI), entendida como “la elección que se lleva a cabo, a nivel territorial, de ciertas actividades económicas, áreas científicas y dominios tecnológicos que son potencialmente competitivos y generados de nuevas oportunidades de mercado en un contexto global frente a la prioridad que otros territorios llevan a cabo” (Del Castilli & Paton, 2013 p. 19). De esta forma, RIS3 tiene como objetivo central desarrollar las “bases metodológicas para facilitar un buen análisis de la competitividad regional, identificar las iniciativas de descubrimiento empresarial que se aprovechan de la diversificación relacionada, llegar a un consenso sobre las acciones y los instrumentos para apoyar estas iniciativas y establecer

compromisos entre todos los agentes implicados" (Del Castilli & Paton, 2013 p. 20).

Con esto en mente, la metodología RIS3 está dirigida hacia autoridades administrativas, *policy-makers*, y profesionales en el desarrollo en las regiones buscando principalmente "una priorización que tiene lugar, a nivel territorial, en actividades económicas, ámbitos científicos y dominios tecnológicos que son potencialmente competitivos y generadores de nuevas oportunidades comerciales" (Barroeta et., 2017 p. 19).

Esta metodología se basa en 6 etapas no lineales que se describen a continuación Foray et al., 2012).

1. Análisis del contexto regional y el potencial de innovación: en este punto se realiza una caracterización de la región a través de un análisis de los activos con los que el territorio cuenta. Asimismo, se identifican las ventajas competitivas y los nichos de sector, existentes y emergentes, para la especialización inteligente.
   Para esto se puede hacer uso de métodos de recopilación de información tales como estudios de caso, entrevistas a actores clave, encuestas, caracterización regional (regional profiling) y análisis de prospectiva (Sörvik, 2012). Esta etapa permite analizar y evaluar el potencial para la innovación, lo que es central para definir el proceso de priorización.
2. Gobernanza para el impulso de la participación, compromiso y colaboración de actores del sistema de innovación: en este punto, un diagnóstico lleva a cabo la identificación de los actores relevantes, sus áreas de acción e intereses. La identificación de actores permite al mismo tiempo definir formas de organización que permiten tratar con una amplia variedad de actores, de esta forma los procesos basados en RIS3 son interactivos, regionalmente motivados y basados en el consenso.
3. Elaboración de una visión colectiva para el futuro de la región: este paso implica el desarrollo de una visión compartida del desarrollo económico y la dirección principal de los proyectos estrategicos.
   La principal idea de la visión es movilizar el poder, específicamente el de los actores, de forma tal que éstos se alineen a un proyecto con beneficios comunes. Esta visión debe ser lo suficientemente realista y atrevida como acomodar diversos patrones de desarrollo.
4. Identificación de prioridades: en este punto se realiza una identificación de sectores de atención prioritarios y sectores con potencial de espcialización, crecimiento o diversificación. Implica en esencia que la especialización se debe realizar considerando la inversión que más impactos genere en la economía regional, esto a través de la definición de objetivos concretos y posibles, prioridades horizontales.
5. Definición de políticas mixtas coherentes, mapas y planes de acción (multianuales), esto destacando las líneas de acción consecuentes con las áreas prioritarias, establecimiento de objetivos medibles y de los

mecanismos e instrumentos de aplicación, identificación de grupos objetivos, actores involucrados (recalcando sus responsabildiades) marcos temporales y fuentes de financimiento para la atención de proyectos de innovación regional.

6. Integración de mecanismos de evaluación y monitoreo: en este punto se definen los mecanismos de control y evaluación. Mientras el monitoreo busca verificar que actividades han sido planeadas, las herramientas de evaluación buscan apreciar los efectos de las acciones que fueron llevadas a cabo. Asimismo, mientras el monitoreo corre a cargo de los actores responsables de la implementación, la evaluación idealmente debe ser hecha por entidades independientes.

## 3. METODOLOGÍA

La metodología utilizada para analizar la aplicación del enfoque RIS3, como parte de la implementación de proyectos de innovación prioritarios para la competitividad en la región del Estado de México se basó en la *investigación-acción participativa*[2] (IAP). Esto debido a que los autores del presente documento formaron parte importante de la estructuración del SRI y, en colaboración con actores del ecosistema innovador del Estado de México, trabajaron para la identificación de las problemáticas socioeconómicas y productivas de la región, la democratización del conocimiento, la identificación de prioridades y la construcción de modelos de gobernanza para que, a través del empoderamiento de actores de la triple hélice, impulsar la participación en grupos de trabajo colectivos.

Los métodos de investigación participativa incluyeron la organización de los grupos de discusión, talleres, entrevistas a líderes de sectores seleccionados como prioritarios por su carácter estratégico. También se realizó un análisis de documentos públicos estadísticos y monográficos de la región y de las principales tendencias tecnológicas de los sectores prioritarios.

[2] Está metodología implica un proceso bajo el cual miembros de un grupo o una comunidad, colectan y analizan información en torno a problemas colectivos con el propósito de encontrar soluciones y promover transformaciones sociales e incluso políticas (Balcazár, 2003). Por lo tanto, derivado de la investigación, se identifican las necesidades y prioridades de los grupos, organizando a los actores para la planeación sistemática del proceso de solución de problemas. Uno de los mayores resultados de estas estrategias es el desarrollo de la consciencia crítica de los propios actores, pues el análisis contextual, histórico y circunstancial, es central en el desarrollo de la IAP. Por último, se genera una evaluación de los cambios realizados y los efectos de estos en los actores y en el entorno. Una de las especificidades de la metodología *IAP* es que el ente investigador forma parte de la comunidad, los grupos de estudio o de las unidades de análisis. La investigación-acción es un concepto que impulsa la participación a través de identificar la necesidad de un cambio, el diagnóstico de una problemática y la propuesta de nuevos enfoques resolutivos.

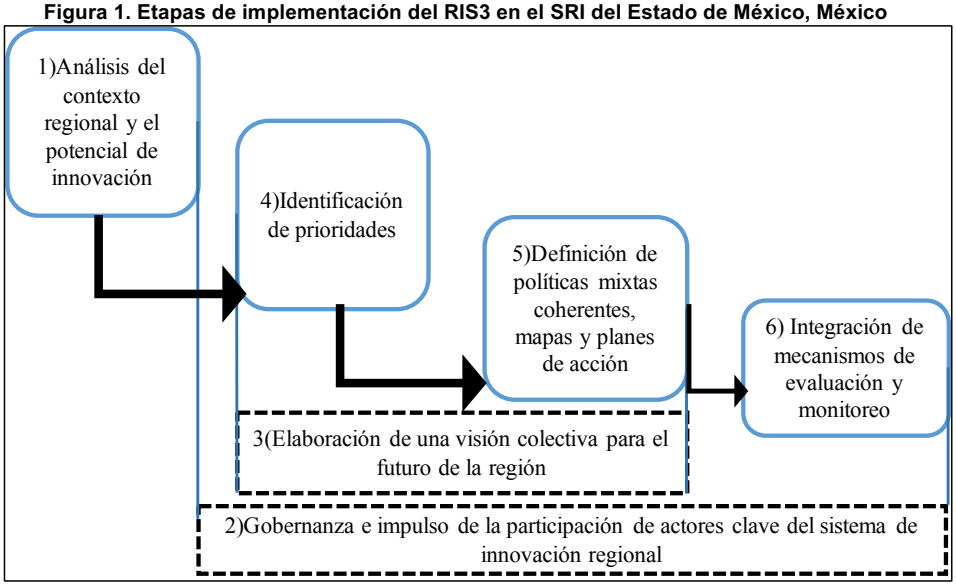
## 4. RESULTADOS

En América Latina, el enfoque de la especialización inteligente ha sido considerada como un elemento impulsor la innovación regional, lo anterior bajo la premisa de impulsar los recursos locales a pesar de la centralización de las políticas de innovación (Barroeta et., 2017 p. 7).

En México, los esfuerzos que en 2014 se llevaron para la construcción de 32 agendas estatales de innovación, y la definición de 495 proyectos estratégicos, constituyeron acciones de dinamización e innovación regional desde el concepto de la especialización inteligente (Idem. p.31).

Recientemente, la metodología RIS3 se aplicó a través de la definición de un marco estratégico del sistema estatal de innovación del Estado de México y la implementación de una Agenda Estatal de Innovación (AEI) para sectores identificados como prioritarios y con potencial competitivo como el sector agroalimentario, aeroespacial, automotriz, plástico, químico y el sector salud-industria farmacéutica en la demarcación.

**Figura 1. Etapas de implementación del RIS3 en el SRI del Estado de México, México**




**Fuente: modificado de Foray et. Al 2012**

El análisis del contexto regional[3] se realizó a través del estudio de datos socioeconómicos y estadísticos de la entidad, identificación de los actores del

[3] El análisis del contexto regional en el Estado de México permitió identificar que ésta demarcación cuenta con 254 empresas del Registro Nacional de Instituciones y Empresas Científicas y

ecosistema de innovación y la definición de los marcos normativos pertinentes para el impulso de actividades de innovación mismo que permitió identificar las vocaciones productivas de la demarcación, destacando a su vez los sectores productivos prioritarios maduros y aquellos emergentes. Se realizaron foros de discusión, reuniones y talleres para la identificación de prioridades y la integración de una cartera con 32 proyectos prioritarios de innovación[4] para la región y los

Tecnológicas (RENIECyT); 391 programas de educación superior acreditados; 156 cuerpos académicos y 1362 investigadores pertenecientes al Sistema Nacional de Investigadores. Asimismo, la demarcación cuenta con un marco normativo de atención a la ciencia, tecnología e innovación (CTI) en su Constitución Política Local, la ley de fomento económico estatal; mientras que el estado cuenta con una comisión de CTI y, hasta el 2018 con 7 programas de innovación estatales. Lo anterior, constituye una masa crítica adecuada para el desarrollo de proyectos de innovación regional. Para estos sectores, es importante mencionar que el estudio del contexto arrojó que el sector agroalimentario del Estado de México (EdoMex) ocupa el primer lugar a nivel nacional con una aportación a la producción bruta nacional del 32.6% y del 32% al valor agregado bruto. Asimismo, en la demarcación se ubican el 25.2% de las empresas de este sector, empleando al 21% del personal ocupado total (INEGI 2014). En cuanto al sector automotriz, el EdoMex ocupa el primer lugar en cuanto al número de unidades económicas, el quinto en cuanto al valor de la producción y el sexto en el personal ocupado. Por otra parte, la industria del plástico y el hule en el EdoMex constituye la de mayor importancia a nivel nacional, ya que esta entidad aporta el 23.1% del total nacional, concentrando el 14% de las empresas del total nacional. En cuanto a la industria química, el EdoMex concentra a la mayor cantidad de empresas dedicadas a este sector (20.53% del total) y ocupa el tercer lugar respecto a la producción total (11.8%). Por otra parte, en cuanto al sector salud, el impacto estatal es de un 17.4% al valor agregado bruto de la producción nacional (INEGI, 2014). Por último, el sector aeroespacial sobresale ya que en el mencionado estado se encuentra uno de los aeropuertos más importantes del país, el aeropuerto internacional de Toluca. Se realizó un estudio de las principales tendencias tecnológicas, es importante mencionar que en cuanto al sector aeroespacial se prestó especial atención a la creación de materiales compuestos, la aviónica, software y hardware. En el sector salud las tendencias se inclinaron hacia las tecnologías sanitarias de prevención, diagnóstico y tratamiento de dispositivos médicos y medicamentos. La digitalización e incorporación de nuevos materiales, motores eléctricos y automatización de procesos se presentó para la industria automotriz. En cuanto al sector agroalimentario, la trazabilidad, inocuidad y empaques destacaron como los elementos de mayor relevancia en este sentido.

[4] Algunos de los proyectos propuestos en el portafolio se mencionan a continuación para cada sector seleccionado.

Sector agroalimentario: Generación de redes de agregación de valor para las diferentes vocaciones regionales de la agroindustria; Desarrollo de un modelo de centro logístico para la comercialización de productos de alto valor agregado de agricultura protegida; Red de integración y vinculación de conocimiento para el fortalecimiento de la cadena productiva sustentable y sostenible del sector pecuario: Desarrollo Integral de la cadena productiva acuícola sustentable en el Estado de México.

Sector automotriz: Red de desarrollo de capacidades en tecnología de materiales (metales y plásticos); Red estatal de unidades para soporte y capacitación en métodos avanzados de ingeniería de producto; Observatorio estatal de la Industria 4.0 para el sector automotriz; Plataforma virtual de articulación entre oferta y demanda de la cadena de proveeduría y capacidades tecnológicas.

Sector químico: Red de investigación sobre métodos y aditivos para el reciclado de materiales plásticos; Observatorio automatizado, sistemático e integral del entorno normativo para la industria química (OASIS); Desarrollo de la plataforma para el manejo, reciclado, recolección y disposición de residuos peligrosos.

Sector plásticos: Red de servicios de evaluación de propiedades funcionales para materiales plásticos y reciclados; Red de laboratorios para el desarrollo de materiales plásticos reforzados y de mayor valor agregado; Red de capacidades para el desarrollo y evaluación de plásticos de alto

sectores seleccionados. En estos foros se contó con la asistencia y participación de actores de la triple hélice[5]. En estos proyectos estratégicos propuestos se definieron los actores a participar, los objetivos a alcanzar, los planes de acción e incluso la definición de presupuestos iniciales. Posteriormente se construyó un plan de implementación de los proyectos propuestos

Para la implementación de los proyectos de innovación propuestos se generó un plan en la agenda en donde se consideraban las acciones y responsables de la implementación de los proyectos, los mecanismos de gobierno que garanticen el desarrollo de los mismo, las metas e indicadores de desempeño de los proyectos, y las estrategias de sinergia con otros instrumentos de política de innovación.

## 5. DISCUSIÓN

A lo largo del proceso de revisión del contexto fue evidente la ausencia de información estadística oficial que fuera congruente y relevante para la caracterización regional, especialmente de aquella que pudiera usarse para el desarrollo de proyectos de innovación. Las bases de datos nacionales adolecen de una marcada descoordinación metodológica lo que dificulta el cruzamiento y verificación de datos, por lo que a pesar de existir censos económicos, éstos no siempre reflejan la realidad de las regiones ni de sus activos[6].

Por otra parte, para la determinación del potencial de innovación fue importante generar un consenso en torno al término mismo de la *innovación*, ya que durante los foros, talleres y espacios de trabajo colaborativo, fue evidente la discrepancia

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desempeño; Generación de una plataforma tecnológica de procesos industriales de alta especialidad para el sector plástico.
Sector salud-industria farmacéutica: Unidad de servicios para pruebas preclínicas; Red estatal de investigación sobre farmacogenómica y teranóstica; Consolidación de la plataforma tecnológica del Estado de México para el diseño, desarrollo de procesos y materiales para dispositivos médicos.

[5] Algunos de los actores fueron instituciones publicas como: COMECYT, Secretaría de Desarrollo Económico (SEDECO), cámaras de comercio como: Cámara Nacional de la Industria de Transformación (CANACINTRA), Confederación Patronal de la República Mexicana (COPARMEX), Cámara Nacional de la Industria Electrónica de Telecomunicaciones y Tecnologías (CANIETI), Asociación Nacional de Fabricantes de Medicamentos (ANAFAM), Comité Normativo Nacional de Consejos de Especialidades Médicas (CONACEM); universidades y centros de investigación como: Universidad Nacional Autónoma de México (UNAM), Universidad Autónoma del Estado de México (UAEM), Colegio de Estudios Científicos y Tecnológicos del Estado de México (CECYTEM), CIATEQ Centro de Tecnología Avanzada, Centro de Ingeniería y Desarrollo Industrial (CIDESI), directores del clúster automotriz, armadores de vehículos, y empresas diversas, por mencionar algunos.

[6] Por mencionar un ejemplo: en México para la identificacion de la masa critica productiva puede hacerse uso de bases de datos nacionales proporcionadas por el Instituto Nacional de Estadistica y Geografía (INEGI) especialmente en sus Encuestas Nacionales de Ocupación y Empleo (ENOE), sin embargo esta información no refleja el potencial economico completo, ya que si consideramos que en México, poco más del 50 por ciento de la población economicamente activa (9.8% localizada tan solo en el Estado de México) se encuentra en la informalidad laboral, el uso de bases de datos oficiales presupone una limitante a la identificación real de los activos regionales (CEFP, 2018).

que existía en torno a la concepción misma, y por ende de las acciones y estrategias a proponer para hacer de esta un medio para llegar al desarrollo. Para solventar esto es necesario crear programas de capacitación continua, para todos los actores del sistema de innovación con el objetivo de estandarizar y unificar el conocimiento en torno a la innovación. Consensuar la epistemología misma de la innovación constituye un reto necesario de vencer dado los actuales cambios políticos y administrativos que en México se están presentando, y que impactan a la región del Estado de México.

Como puede observarse en la figura 1, la participación de actores se promovió desde las primeras etapas de caracterización de las regiones, lo anterior ya que se rescata información cualitativa obtenida desde los actores clave quienes conocen la realidad de sus propios territorios. El valor de la información obtenida mediante entrevistas a profundidad, constituye un activo fundamental para la identificación de líneas de atención prioritarias, pues los actores suelen ser más explícitos al sentirse libres de la presión que ejerce un grupo.

En cuanto a la gobernanza, esta experiencia también ha mostrado que la interacción entre actores de un sistema de innovación requiere un modelo de gobernanza que evite al grupo de actores caer en una dinámica de dispersión.

Mejores modelos de gobernanza favorecen la inclusión de distintos actores del sistema de forma realmente colaborativa y con una visión de largo plazo para el desarrollo de la región. Asimismo, se debe contar con la participación constante de una institución rectora que asuma la coordinación de los actores del sistema. Las experiencias de la RIS3 implementada en Europa son prueba de la necesidad de contar con una institución directora que gestione estas estrategias de desarrollo regional, contribuya a la construcción de un marco de institucional que proporcione guía estratégica y promueva una cultura de colaboración (existen ejemplos de implementación exitosa de la estrategia RIS3 coordinadas por instituciones tales como el caso de: la Agencia Regional para la Innovación y la Tecnología- Francia Centre Val de Loire; Secretaria Federal de Educación e Investigación Alemania; Consejo de investigación e innovación regional- Grecia Epirus; Oficina Nacional de Investigación, Desarrollo e Innovación- Hungría; Comisión de Coordinación y Desarrollo Centro Regional- Portugal por mencionar algunos (European Union, 2016). Sin embargo, no debemos olvidar que la presencia de una institución coordinadora a nivel regional es condición necesaria, más no suficiente, para llevar a cabo una especialización inteligente.

En este mismo sentido, la metodología RIS3 debe ocurrir en un marco institucional estable, elementos que no se presentan para el caso de estudio mexicano, ya que en el Estado de México, el Consejo Mexiquense de Ciencia y Tecnología, COMECYT como institución rectora atravesó recientemente por una serie de cambios administrativos y de dirección, lo que ha generado gran inestabilidad y cambios de prioridades que hacen que las estrategias se desdibujen.

La falta de continuidad en los planes y programas de desarrollo y la fatuidad política, son una de las mayores debilidades del sistema político mexicano, lo que afecta profundamente la sostenibilidad de los sistemas de innovación.

De igual forma, es de mencionar que gran parte de los proyectos prioritarios desarrollados en los ejercicios de colaboración participativa, están enfocados a la construcción de redes de cooperación entre actores al amparo de un marco institucional que genera derechos y obligaciones a los participantes. Lo anterior es sintomático de una necesidad no atendida de vinculación entre instituciones y refleja un sistema de innovación qué se siente desarticulado entre sí.

Es de mencionar que, para la implementación de metodologías como RIS3 en el contexto mexicano, es importante considerar que un factor de éxito para el logro de las metas establecidas es fortalecer los liderazgos en los grupos de interés, en los cuales se incluyen actores del sector empresarial, gubernamental, municipal y académico, pues de esa manera se puede lograr la meta de llevar los beneficios a los distintos grupos del estado.

En cuanto a la construcción de un marco normativo y de políticas públicas para la implementación de los proyectos de innovación regional, en el caso del estado de México es necesario tomar en consideración que los proyectos que estén dentro de los sectores marcados como estratégicos deben considerarse como prioritarios, pues esto contribuiría a tener una focalización en el destino de los recursos regionales, asimismo, es pertinente alinear los instrumentos y recursos de todas las instituciones de apoyo, para potenciar sus impactos.

El manejo óptimo de los recursos constituye uno de los principales objetivos de la implementación de metodologías como la RIS3, y da paso al tema del financiamiento necesario para la sostenibilidad del SRI. El financiamiento público al desarrollo tecnológico contribuye, complementa y estimula las inversiones privadas en investigación y desarrollo, generando una dualidad de beneficios tanto por atender necesidades propias del estado como de las empresas. Por lo tanto, el financiamiento al SRI debe estar basado en una estrategia compartida en la que los fondos provengan de distintas fuentes- Ante esto, se pueden generar fondos cooperativos de inversión privada y gubernamental que se apliquen concretamente a los proyectos que constituyen la agenda de innovación del estado.

Para lograr modelos de financiamiento cooperativo también es necesario adecuar las reglas de operación de los programas actuales de CTI para dar cabida y privilegiar proyectos en donde se proponga el trabajo colaborativo entre diferentes organizaciones (Centros de Investigación –Instituciones de Educación Superior (IES); IES – empresas; empresa – empresa, etc.).

El financiamiento de un SRI atiende también a las necesidades de fortalecer las capacidades científicas y tecnológicas del recurso humano para crear especialistas en las áreas tecnológicas de los proyectos de innovación regional, lo

que puede fomentarse con el fortalecimiento de programa de becas para niveles superiores y de posgrado, mismos que puedan apoyar al mayor número de instituciones posibles, empresas incluidas.

Es importante destacar que hasta finales de 2018 existían diversos programas federales de apoyo a los que se podía recurrir bajo el marco de la presente experiencia detallada; sin embargo, con los cambios políticos y administrativos en México derivados de la llegada de un gobierno de otro partido, muchos de ellos han sido cancelados por lo que los fondos a los que se puede recurrir para este efecto son los propios de la institución rectora del Estado de México como COMECYT, fondos federales o estatales específicos, apoyos internacionales provenientes de organismos multilaterales, acuerdos de cooperación técnica o fundaciones privadas sin fines de lucro.

Por último, la evaluación y monitoreo de las políticas de innovación, sigue siendo un asunto pendiente en las agendas locales y nacionales. El monitoreo permite conocer si el programa implementado, y los proyectos que de este se generan, son consecuentes con las necesidades detectadas y su gestión es la correcta mientras que el elemento de evaluación se remite a conocer si los objetivos planteados fueron alcanzados y si el resultado de la acción fue el deseado.

Es de destacar que mediante las actividades de monitoreo se realiza un acompañamiento midiendo los resultados parciales de las acciones emprendidas, evaluándolas en función de indicadores de desempeño previamente definidos. Por su parte, la evaluación mide los resultados e impactos del programa y sus proyectos, con base en lo que se haya contemplado en el marco lógico, incluyendo el conjunto de indicadores asociados al objetivo de desarrollo (Solleiro & Sánchez, 2015).

Considerando lo anterior, y para medir el desempeño de un SRI es importante comprender que los sistemas de innovación son complejos, por lo tanto, se espera que existan correlaciones entre las medidas utilizadas para caracterizar o medir su desempeño. Estas correlaciones se pueden usar para construir indicadores y modelos independientes de la escala (ajustados por la escala) que están realmente normalizados. Los indicadores independientes de la escala pueden informar con mayor precisión a los tomadores de decisiones sobre los resultados que contribuyen a un sistema de innovación.

En el caso del SRI del estado de México y la implementación de la AEI es posible platear indicadores cuantitativos de monitoreo y de evaluación como los mencionados a continuación:

a) Indicadores de monitoreo, para identificar el progreso en la implementación de los proyectos de la agenda: Número de buenas prácticas o técnicas implementadas; número de convenios de colaboración entre empresas, instituciones de educación y centros de investigación; aumento en el gasto de cti por parte de las empresas regionales; número de centros de cooperación entre sectores académico y empresarial, entre otros.

b) Indicadores de evaluación que permitirán medir el impacto en el mediano y largo plazo: Número de proyectos de investigación conjunta contratados entre empresas e IES o CI; número de nuevos productos o procesos en el mercado; aumento en el número de empresas tecnológicas en cada sector; número de instituciones certificadoras en el estado; aumento en el volumen de las exportaciones en el estado, de empresas en los sectores prioritarios; aumento de empresas en los eslabones superiores en la cadena de valor, entre otros.

Sin embargo, para complementar el sistema de indicadores cuantitativos que dejan de lado el análisis de insumos e impactos, la inclusión del concepto de adicionalidad en la evaluación de actividades de innovación regional cobra relevancia.

El enfoque de adicionalidad (Buisseret et al., 1995), define los beneficios obtenidos como resultado de la intervención pública, mismos que no existirían de no ser por dicha intervención. Este enfoque metodológico puede considerar elementos como la adicionalidad de insumos, la cual está relacionada con los gastos que diversos actores realizan en actividades de CTI; la adicionalidad de resultados; adicionalidad de valor agregado que se refiere a los excedentes que no podrían haberse obtenido sin la presencia del apoyo, e incluso la adicionalidad de comportamiento, la cual considera una serie de cambios en los agentes a partir de la recepción del apoyo y que pueden presentarse en modificaciones de las rutinas, habilidades o conocimientos.

## 6. CONCLUSIONES

A pesar de que la metodología RIS3 coloca a la innovación como palanca de éxito para el desarrollo y contribuye a la eficiencia de las inversiones públicas a través de la especialización inteligentes, es importante analizar experiencias como las del presente documento a fin de identificar los factores claves, retos y oportunidades que se presentan en el proceso de implementación y desarrollo de estas estrategias en países con realidades divergentes, sistemas de innovación frágiles o incipientes, niveles de inversión inferiores al recomendado por la OCDE, y en donde las condiciones más elementales para el desarrollo pueden no estar presentes o ser deficientes.

Es pertinente considerar la construcción o diseño de una metodología de especialización inteligente para regiones de países en desarrollo, como el caso de México y muchos países de América Latina, los cuales no cuentan con el mismo nivel de maduración en sus sistemas de innovación. Las limitaciones de la metodología constituyen ventanas de oportunidad para el estudio de la especialización inteligente (*RIS3$_{DC}$ Developing countries*).

Con esto en mente, nuevas líneas de investigación en torno a la metodología RIS3 se abre al análisis tales como la propuesta de construcción de indicadores mixtos que reflejen mejor los efectos de las intervenciones, y en donde enfoques como el

de la adicionalidad para la evaluación de impacto de los programas puedan ser incluidos.

Otro elemento de estudio puede ser el análisis y diseño de instrumentos de política que faciliten la construcción de nuevos modelos de financiamiento compartidos para la inversión colaborativa privada y pública.

Por otra parte, es necesario considerar modelos de gobernanza, flexibles pero firmes, que disminuyan los efectos negativos de los cambios administrativos y de política que se presentan periódicamente y que ponen en riesgo la continuidad de proyectos prioritarios y la sostenibilidad de los sistemas de innovación.

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## 5.2 E2. Obstacles to innovation as effect on productivity in small developing countries - Fernando de Oliveira, Óscar Rodil-Marzábal

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*OBSTACLES TO INNOVATION AS EFFECT ON PRODUCTIVITY IN SMALL DEVELOPING COUNTRIES*

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ABSTRACT

This paper aims to analyse the influence of perceived obstacles to innovation on the economic performance of potentially innovative firms in small developing countries. In particular, the study focuses on the effects that different difficulties in achieving innovation exert on general productivity and innovation productivity, thus satisfying a perspective that is very little explored by the innovation literature that considers the obstacles as explanatory variables of the output's organizations. In particular, the study focuses on the effects that the different difficulties in carrying out innovation have on general productivity and the productivity of innovation, thus satisfying a perspective very little explored by the innovation literature that considers obstacles as explanatory variables of organisational outputs. The empirical analysis is based on panel data of 3,098 companies from the Uruguayan Community Innovation Survey (CIS) for the period 2001-2015. Unlike more conventional research, which contrasts innovative companies from non-innovative companies, this work performs a model of generalized estimating equation (GEE) in potentially innovative companies for a better understanding of the differences between the types of productivities. This type of cohort tends to capture more satisfactorily the innovative propensity in developing countries, due to the fact that the innovation process shows different dynamics from those found in countries closer to the technological frontier. In general, the results show a certain internal homogeneity of the obstacles in relation to the different types of productivity studied. Productivity generated from innovative goods and services showed a negative relationship with the different difficulties in innovating, while problems related to market factors are the only ones that show a negative and significant relationship with the productivity resulting from more conventional products. In particular, due to characteristic aspects of proportionality, the effects of obstacles, while they are fundamental to innovative productivity, produce less relevant effects for productivity as a whole. These results suggest that actions focused on qualifying the training and access of qualified personnel in potentially innovative companies may be important to raise both productivity rates.

*Keywords:* obstacles to innovation; productivity; potentially innovative firms; Uruguay.

*Classificação JEL:* O33; O54; J24.

# *OBSTÁCULOS À INOVAÇÃO COMO EFEITO À PRODUTIVIDADE EM PEQUENOS PAÍSES EM DESENVOLVIMENTO*

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## RESUMO

Este artigo tem como objetivo analisar a influência da percepção dos obstáculos à inovação sobre a performance econômica das empresas potencialmente inovadoras em pequenos países em desenvolvimento. Em particular, o estudo centra-se nos efeitos que as diferentes dificuldades em realizar inovação exercem sobre produtividade geral e a produtividade da inovação, satisfazendo, dessa forma, uma perspectiva muito pouco explorada pela literatura da inovação que considera os obstáculos como variáveis explicativas dos outputs organizacionais. A análise empírica é baseada em dados de painel de 3.098 empresas a partir da *Encuesta de Actividades de Innovación en la Industria* uruguaia para o período 2001-2015. Diferentemente das pesquisas mais convencionais, que contrastam empresas inovadoras de empresas inovadoras, este trabalho executa um modelo de equação de estimativa generalizada (GEE) em empresas potencialmente inovadoras para uma melhor compreensão das diferenças existentes entre os dos tipos de produtividades. Esse tipo de coorte tende a captar mais satisfatoriamente a propensão inovadora em países em desenvolvimento, dado que o processo de inovação apresenta dinâmicas distintas daquelas encontradas em países mais próximos da fronteira tecnológica. Em geral, os resultados denotam certa homogeneidade interna dos obstáculos na relação com os diferentes tipos de produtividade estudada. A produtividade gerada a partir de bens e serviços inovadores apresentaram relação negativa com as diferentes dificuldades em inovar, enquanto os problemas relacionados a fatores de mercado são os únicos que mostram uma relação negativa e significativa com a produtividade resultante dos produtos mais convencionais. Particularmente, devido a aspectos característicos de proporcionalidade, os efeitos dos obstáculos ao tempo que são fundamentais para a produtividade inovadora, produzem efeitos menos relevantes para a produtividade com um todo. Estes resultados sugerem que ações focadas em qualificar a formação e acesso de pessoal qualificado nas empresas potencialmente inovadoras podem ser importantes para elevar ambos índices de produtividade.

***Palavras-chave:*** obstáculos à inovação; produtividade; empresas potencialmente inovadoras; Uruguai.

***Classificação JEL:*** O33; O54; J24.

SCIENTIFIC AREA ACCORDING TO THE CONGRESS LIST: "Innovation and technological development in the world economy".

IS IT CANDIDATE TO THE **JOSÉ LUÍS SAMPEDRO PRIZE/AWARD**? "**YES**"

## 1. INTRODUÇÃO E ANTECEDENTES

A predominância de estudos que consideram a inovação como condição para o incremento da produtividade é, sem lugar a dúvidas, um desafio para este estudo. Em geral, determinados resultados apontam para uma linha específica presente nos estudos sobre os obstáculos, que considera a relação entre categorias determinantes das empresas e a percepção dos obstáculos. De maneira inversa, a perspectiva deste trabalho buscará considerar os efeitos dos obstáculos à inovação sobre a performance da empresa. A opção pelos obstáculos à inovação em lugar da inovação como variável explicativa consiste em estratégia sensível, pois considera esses mesmos obstáculos como condição prévia ou adjacente à implementação da inovação.

A opção por essa estratégia tende a apresentar determinada consistência lógica, dado que nesse conjunto estão incluídas empresas inovadoras e não inovadoras que são sensíveis as dificuldades em inovar. Para a finalidade da análise, o uso mais extensivo que confere os efeitos dos obstáculos sobre a performance da empresa pode configurar-se em uma estratégia mais delimitada que a inovação propriamente dita. De acordo com a literatura, o fato de a empresa realizar inovação não necessariamente corresponde a uma menor percepção dos obstáculos (D'Este et al, 2012; 2014). Assim, se uma dedução nessa linha é de fato possível, a produtividade da empresa não se estabeleceria somente pela razão entre os resultados econômicos gerados e o número de empregados, mas também poderia ser interpretada pela capacidade explicativa da percepção dos obstáculos sobre a própria performance econômica. Não obstante, apesar de que tal entendimento seja de alguma forma incipiente, esta perspectiva possibilita abrir um espectro de análise e interpretação ainda em aberto e que permite complementar analiticamente essa relação.

O estudo de Coad et al. (2016), na prática, corresponde a um trabalho seminal que se implica em atuar neste campo. O anseio de integrar essa linha empírica presente na literatura, que considera os efeitos dos obstáculos sobre uma variável concreta, e aplicá-lo à produtividade, em palavras menores, possibilita verificar os efeitos de aprendizagem que se desenvolvem a partir da relação produtiva. Em estudos anteriores os efeitos de aprendizagem foram capazes influenciar a relação entre as características e determinantes organizacionais e os obstáculos à inovação (D'Este et al., 2012). Nesta ocasião, será satisfatório identificar o efeito que os obstáculos podem produzir, em perspectiva diversa, sobre a performance econômica da empresa.

Numa revisão prévia, cabe destacar que a interpretação sobre a performance econômica da empresa pode assumir distintas direções. O debate sobre a importância de *inputs* e *outputs* da inovação no incremento da produtividade é substancial para compreender que a P&D é satisfatória (Lööf, 2005), porém não exclusiva de verificação, já que os *outputs* se configuram como resultados fundamentais à mensuração da produtividade da firma. Em geral, são os esforços para desenvolver

produtos e processos, traduzidos em resultados imediatos, os facilitadores da produtividade e outras performances econômicas (Crepon et al., 1998).

Por outro lado, a inovação propriamente dita nem sempre se apresenta como indicador principal para se verificar as potencialidades inovadoras de uma organização. Os dispêndios e a prática em atividades inovadoras são tão eficazes para interpretar o comportamento inovador quanto o resultado final em si. Os estudos iniciais vinculados à economia da inovação ou se limitavam em considerar a inovação na sua forma concreta, ou tendiam a considerá-la apenas por seu caráter tecnológico. Quando muito, reduziam-se em ponderar a P&D como elemento senão único, basilar para interpretar o processo inovador; isso para não citar que em décadas anteriores as estatísticas de proteção intelectual compuseram o indicador padrão para a métrica da inovação em países desenvolvidos. É apropriado mencionar que essas elaborações foram geralmente suscitadas pela carência de informações mais específicas, num contexto em que a P&D formal, realizada em sua maioria por grandes empresas, representava uma referência central da implementação e dinamismo da inovação (Schumpeter, 1942).

Na atualidade a configuração entre organizações e países assumem formas e expectativas distintas. Em consequência disso, os manuais mais recentes tendem a incluir a inovação organizacional e de mercado somados à perspectiva mais convencional da inovação de produto e processo (OECD, 2005; 2018). Além disso, os manuais abrem campo para a inclusão da inovação em serviços, claramente induzido pela tendência de uma maior importância do setor terciário na estrutura econômica dos países mais desenvolvidos. No que corresponde as atividades inovadoras, uma minoria de empresas se restringe a execução da P&D formal, gerida em departamentos específicos. As atividades inovadoras tendem a adquirir um comportamento mais transversal à organização e na maioria dos casos podem ultrapassar os limites da própria empresa. Abordagens teóricas que consideram a *open innovation* como modelo teórico interpretativo, lançam luz para um comportamento inovador mais interdependente ao ecossistema em que habita (Chesbrough, 2003).

De modo geral, existem evidencias concretas concernentes a relação entre a P&D, a inovação e a produtividade no nível da empresa em países industrializados (Griffith et al., 2004, 2006; Lööf, 2005; Mairesse e Mohnen, 2010; Mohnen e Hall, 2013; Baumann e Kritikos, 2016). Estudos demonstram existir um círculo virtuoso entre esses elementos que são capazes de produzir taxas de crescimento sustentáveis a longo prazo, gerando uma fonte de vantagens diretas e indiretas para as empresas (Hall e Jones 1999; Rouvinen, 2002; Guloglu e Tekin, 2012). De forma específica, a P&D facilita a capacidade absortiva das organizações, ampliando o estoque de conhecimento através da identificação, assimilação e uso da tecnologia produzida externamente (Cohen e Levinthal, 1989, 1990; Griffith et al., 2004). Essa capacidade tende a fortalecer as capacidades tecnológicas internas da empresa, resultando no aparecimento de *spillovers* de conhecimento, possibilitado tanto pela aquisição de tecnologias externas (máquinas, equipamentos, novos processos, etc.), como pela interação e cooperação com demais empresas e instituições. Seguindo esta sequência lógica, o círculo virtuoso tende a auto completar-se, contribuindo tanto para a geração de novas inovações como para a produtividade das empresas.

O modelo recursivo MDL (Crépon-Duguet-Mairesse) proposto por Crépon et al. (1998) se configurou como uma das primeiras propostas em estimar os investimentos realizados em inovação

em forma de P&D. Este modelo, considerando os resultados de inovação realizados por empresas individuais no contexto francês, reforça a correlação positiva entre a produtividade da empresa e o maior resultado de inovação, mesmo controlando a composição das habilidades do trabalho. Os autores também confirmam que a decisão de uma empresa investir em inovação (P&D) possui relação positiva com o tamanho, com a participação de mercado e diversificação, e com as forças de demanda e atração de tecnologia. Apesar de centrar-se em resultados de empresas individuais, a análise microeconômica aplicada tem o potencial de esclarecer os fundamentos das correlações encontradas no nível macro, pormenorizando informações relacionadas ao país ou setor.

Projetando-se sobre o contexto latino-americano, diferenças tendem a confirmar as disparidades de produtividade no âmbito territorial e setorial (Busso et al., 2013). Para citar apenas algum exemplo, é comum verificar empresas pertencentes ao setor de informática apresentando estruturas organizacionais e comportamentais bastante diversas em termos de atividades inovadoras, que, por conseguinte se traduz na capacidade produtiva da empresa. De forma complementar, é possível interpretar que as classificações de atividades econômicas tendem a enquadrar certas atividades em um espectro mais extenso de atuação, comparando empresas dedicadas a manutenção de software e equipamentos informáticos a outras que requerem P&D de alta complexidade. De forma geral, a região se caracteriza pela existência de um número elevado de empresas de baixa produtividade, coexistindo com um número menor de empresas de alta produtividade (Pagés, 2010; Lavopa, 2015). O Banco Interamericano de Desenvolvimento parece verificar empiricamente esse comportamento. Analisando a distribuição da produtividade laboral entre 10 e 90 percentis, o setor manufatureiro apresenta uma diferença aproximada de 10:1, em que a maioria de empresas se agrupam em níveis mais baixos de produtividade, coexistindo com poucas empresas altamente produtivas. Essa tendência se estende ao setor de serviços, apesar do viés ser precisamente mais recorrente entre as manufaturas, que apresenta maior concentração de empresas de baixa produtividade (Grazzi et al., 2016).

A interação entre fatores específicos das empresas pode resultar certa heterogeneidade no crescimento da produtividade, gerando diferenças intersetoriais no interior dos próprios setores (Syverson, 2011), e também entre os obstáculos percebidos. De acordo com essa linha, o estudo de Coad et al. (2016) retrata de forma original a heterogeneidade existente nas empresas potencialmente inovadoras, e eleva a discussão particularizando o comportamento da empresa segundo sua performance econômica e a relação com os obstáculos. Anteriormente já havia sido discutido que estes autores assumem uma das linhas orientativas que investiga os efeitos que estabelecem os obstáculos sobre uma variável determinada, contudo, vão mais além ao demostrar uma distribuição mais equitativa em termos de produtividade para o contexto britânico. Diferentemente do que parece ocorrer nos resultados para a América Latina, a distribuição quantil aplicada é mais equilibrada e apresenta uma sútil tendência de aglomeração em empresas com maior produtividade. Apesar de não estabelecer variáveis comparativas entre setores, a análise mostra comportamentos praticamente idênticos ante a uma relação negativa entre as barreiras à inovação de caráter econômico e a produtividade das empresas. Por outro lado, as dificuldades vinculadas a fatores de conhecimento, de mercado ou regulatórios não são significativas em praticamente todos os quantis que aglomeram as empresas por produtividade. Apenas as empresas situadas no quantil mais produtivo mostra relação significativas, cujos os obstáculos vinculados a

fatores regulatórios apontam uma relação negativa, enquanto que a falta de informação sobre tecnologias e mercados apresentam uma relação positiva com a produtividade nesta agrupação.

Não caberia extrair nesse momento interpretações maiores, porém a relação positiva de uma parcela dos fatores de conhecimento com as empresas mais produtivas da distribuição sugere um fenômeno de aprendizagem verificado ao longo do processo inovativo. Analogamente aos últimos trabalhos que tratam os obstáculos (por exemplo, D'Este et al. 2012; 2014), as execuções das análises são baseadas na seleção de empresas potencialmente inovadoras, ou seja, aquelas empresas que mesmo não implementando inovação, tiveram a intenção de inovar. A literatura especializada vem justificando que essa característica organizacional reduz possíveis vieses nos resultados em comparação com estudos que se limitavam a considerar apenas empresas inovadoras ou não inovadoras. A enquadramento das potencialmente inovadoras produz, nesse sentido, um enfoque mais delineado. A estratégia de Coad et al. (2016) permite ver que a percepção de (alguns) fatores de conhecimento adquire uma relação positiva com as organizações de maior produtividade, dado a clareza e o melhor entendimento daqueles aspectos que propriamente dificultam a inovação. Divergindo daquilo que se pôde considerar inicialmente, não seria tanto a falta de informação que estabeleceria relação sobre a produtividade, mas sobretudo a consciência das dificuldades deste tipo de fatores sobre a inovação e consequentemente sobre a produtividade da empresa. Mesmo que minimamente, é pertinente considerar o componente de aprendizagem oriundo desta relação, dado que o conjunto de empresas mais produtivas poderiam ser as que mais efetivamente percebem esse tipo específico de obstáculo e não o oposto.

Dessa forma, enquanto outros estudos buscam verificar a relação entre os obstáculos e os elementos da estrutura organizacional, o objetivo deste artigo consiste em compreender os efeitos dos obstáculos à inovação sobre a performance econômica da empresa. A abordagem revisitada na literatura, cujas dificuldades que se deparam as empresas durante a processo e/ou implementação da inovação e a respectiva relação com a produtividade organizacional, oferece uma oportunidade analítica singular tanto em termos metodológicos quanto em relação a sua proposta territorial. O estabelecimento de empresas potencialmente inovadoras na análise, em lugar da tradicional divisão entre inovadoras e não inovadoras, abre um campo de ação que se verifica fortalecido quando aplicado a um pequeno país em desenvolvimento.

A utilização da série histórica de empresas uruguaias, disponibilizadas pela *Agencia Nacional de Investigación e Innovación*, oferece a possibilidade de entender as relações produzidas a partir dos efeitos da percepção dos obstáculos em uma condição de heterogeneidade, e estende o debate sobre territórios com menor tradição na aplicação deste tipo de estudo. Adicionalmente, cabe ratificar que para além da seleção das empresas na composição e execução da análise longitudinal e da delimitação territorial, a principal novidade proposta aqui se encontra na síntese e substituição da clássica categoria inovação pelo uso dos fatores específicos que dificultam essa inovação. Entende-se, dessa forma, que possíveis efeitos de aprendizagem gerados a partir de tal identificação, integra-se e dialoga com uma das linhas principais da literatura sobre os obstáculos, e que poderão ser verificados e compreendidos conforme avance o trabalho.

Assim, este artigo organiza-se da seguinte forma. O modelo empírico e os dados são descritos nas Seções 2 e 3, respectivamente A Seção 4 apresenta e discute os principais resultados e a parte final apresenta as conclusões.

## 2. DADOS

Os dados ao nível da empresa que compõe a análise são obtidos a partir da *Encuesta de Actividades de Innovación en la Industria Uruguaya* (EAIIU) em cinco diferentes edições: 2001-2003, 2004-2006, 2007-2009, 2010-2012 e 2013-2015. A EAIIU é o resultado da *Colección de Indicadores y Estudios* surgidos da análise de informação sobre o *Sistema de Ciencia, Tecnologia e Innovación*, elaborados pela *Agencia Nacional de Investigación e Innovación* (ANII), cujo principal objetivo é difundir informações que possibilitam a elaboração, o seguimento e a avaliação de diferentes instrumentos de que constituem em instrumento estratégico para a tomada decisões em matéria de políticas em ciência, tecnologia e inovação.

A EAIUU se fundamenta nos delineamentos conceituais e metodológicos do Manual de Bogotá (RICYT, 2000), elaborado e publicado pela *Red Iberoamericana de Indicadores de Ciencia y Tecnología* (RICYT) em parceria com a *Organización de Estados Americanos* (OEA). O Manual de Bogotá, que tem como referência o Manual de Oslo (OECD, 2005), busca estabelecer um equilibro entre os critérios definidos neste último e incorporar instrumentos específicos que sejam capazes de reconhecer as particularidades do comportamento tecnológico e inovador das empresas pertencentes aos sistemas de inovação dos países da América Latina.

De forma geral, a pesquisa está agrupada em quatro grandes áreas temáticas: atividades de inovação, resultados das atividades inovadoras, fatores que dificultam a inovação e a vinculação com o SNI. Com o intuito de elaborar uma diferenciação entre os diversos tipos de perfil de empresas, os dados são caracterizados de acordo com o comportamento inovador, estratificação do porte[1], origem do capital[2] e atividade econômica da empresa. As amostras empregadas nas quatro edições da EAIIU estão em consonância com as cinco edições da *Encuesta Anual de Actividad Económica* publicada nos anos 2003, 2005, 2008, 2010 e 2013, seguindo um método misto de elaboração que converge uma aproximação de tipo censitário com amostragem aleatória estratificada.

As quatro edições da EAIUU trabalham com o universo total da indústria manufatureira do Uruguai (capítulo D, divisões 15 a 36 da Classificação Internacional Industrial Uniforme Revisão 3 (CIIU ver. 3), extraindo da população amostras de empresas manufatureiras com cinco ou mais empregados. A edição 2001-2003 considerou uma amostra aleatória de 828 empresas das quais 814 empresas responderam efetivamente a pesquisa, representando uma taxa de resposta de 98%. A edição 2004-2006 foi composta por uma amostra aleatória de 845 empresas, sendo respondida por 822 empresas (97%). A edição 2007-2009 foi composta por uma amostra aleatória de 1.040

[1] A estratificação do porte da empresa é realizada de acordo com o número de pessoas ocupadas, definindo-se como pequena empresa aquela entre 5 e 19 empregados, como média empresa aquela entre 5 e 499 empregados, e grande empresa a organização com 500 ou mais empregados.

[2] A origem do capital da empresa é determinada pela composição de capital nacional ou estrangeiro. Empresas nacionais são consideradas aquelas cujo capital nacional representa 100% da totalidade do capital, enquanto empresas de capital estrangeiro ou misto são aquelas que apresentam alguma participação de capital estrangeiro, independente da sua proporção.

empresas, sendo efetivamente respondida por 924 organizações (88,8%). A edição 2010-2012 foi respondida por 1.814 empresas, o que representa uma taxa de reposta de 85% de um total de 2.134 empresas. Finalmente, a edição 2013-2015 considerou uma amostra aleatória de 2.481 empresas, representando uma taxa de resposta de 86% (2.494 empresas) (ANII, 2005; 2008; 2012; 2014; 2017).

Os mesmos conceitos desenvolvidos pelo Manual de Bogotá foram utilizados para a configuração da EAIUU. As empresas denominadas inovativas foram as unidades econômicas que, nos períodos correspondentes à coleta dos dados das respectivas edições, realizaram alguma atividade de inovação. Cabe ressaltar que essa perspectiva difere das perspectivas clássicas que consideram empresas inovadoras somente aquelas que implementam inovação, a exemplo da estratégia utilizada pelo questionário equatoriano. A metodologia do Manual de Bogotá evidencia determinada intencionalidade de flexibilizar a classificação de empresas situadas em regiões mais periféricas, cujo carácter da inovação alcança parâmetros mais pragmáticos e que nem sempre a inovação pode ser traduzida por uma implementação exata. Para efeitos analíticos, o trabalho segue uma estratégia semelhante a utilizada pela EAIUU, no entanto idêntica à metodologia empregada na recente literatura sobre os estudos dos obstáculos à inovação ao considerar empresas potencialmente inovadoras em lugar da divisão clássica entre inovadoras e não inovadoras (D'Este et al, 2012; 2014). Para tanto, a amostra é classificada e selecionada de acordo com o respectivo potencial inovador. Empresas potencialmente inovadoras são aquelas que apesar de não realizar alguma inovação concretamente, mostram-se predispostas a realizar a mesma, independentemente se a inovação foi implementada. Empresas que realizaram ao menos uma atividade de inovação são incluídas na seleção tanto quanto empresas que não chegaram a efetivar atividades de inovação, mas que avaliaram um ou mais obstáculos como alta ou média importância para a implementação de inovação. Verifica-se, portanto, que a amplitude da amostra confere importância à análise das empresas que demostraram algum comprometimento em inovar.

## 3. MODELO EMPÍRICO

### 3.1. MÉTODO E VARIÁVEIS DEPENDENTES

Esta seção apresenta uma visão geral do método analítico empregado e realiza uma descrição das variáveis dependentes incluídas na análise. A tabela 1 apresenta um resumo estatístico de todas as variáveis incluídas na amostra.

Um painel de dados é utilizado para verificar a associação entre as variáveis. Como descrito acima, é considerada uma amostra das empresas potencialmente inovadoras a partir do universo total da indústria manufatureira de Uruguai no período 2001-2015. Em relação ao tipo das variáveis dependentes analisadas, emprega-se dois modelos para a estimação. Ambas variáveis dependentes usadas na análise empírica (*lnProdutiv* e *lnProdutiv_inov*) assumem uma distribuição logarítmica. Em comparação a primeira, a segunda variável é levemente mais inclinada à direita, contendo um maior número de zeros. Uma maneira de lidar com esses recursos específicos de dados é usar o modelo de equação de estimativa generalizada (GEE), o que permite estimar os parâmetros de um modelo linear generalizado em dados de painel (Liang e Zeger, 1986). De forma

geral, o modelo padrão GEE assume que as observações ausentes sejam estimadas aleatoriamente por meio da técnica de *missing completely at Randon* (MCAR) (Little & Rubin, 1987).

Tabela 1. Estatística descritiva das variáveis

| Variável | Obs. | Média | D. Padrão | Min. | Max. |
|---|---|---|---|---|---|
| ln_produtiv | 6.111 | 2,34 | 0,39 | 0,80 | 3,02 |
| ln_produtiv_inov | 1.397 | 4,57 | 0,45 | 1,16 | 5,31 |
| obst_conhe | 6.155 | 0,40 | 0,49 | 0,00 | 1,00 |
| obst_econo | 6.155 | 0,45 | 0,50 | 0,00 | 1,00 |
| obst_merca | 6.155 | 0,48 | 0,50 | 0,00 | 1,00 |
| obst_insti | 6.155 | 0,36 | 0,48 | 0,00 | 1,00 |
| lntamanho | 6.141 | 3,70 | 1,34 | 0,00 | 9,11 |
| exporta | 6.155 | 0,29 | 0,46 | 0,00 | 1,00 |
| alta_educ | 5.504 | 0,09 | 0,14 | 0,00 | 1,00 |
| ln_idade | 5.382 | 0,30 | 0,10 | 0,00 | 2,37 |
| inov_org | 4.523 | 0,27 | 0,45 | 0,00 | 1,00 |

*Fonte:* Elaboração própria a partir dos dados da ANII (2005; 2008; 2012; 2014; 2017).

Similar aos modelos lineares generalizados (GLMs), o GEE permite relações não-lineares entre variáveis independentes e a variável dependente. Além disso, a abordagem GEE atenua alguns pressupostos do GLM e permite estruturas correlacionadas de dados agrupados (Sandulli et al., 2012). O GEE possibilita relacionar uma variável de resposta que segue uma distribuição normal a uma variável preditora em termo linear por meio de uma distribuição adequada da variância (*family*) e função de ligação (*link*). Considerando que as variáveis de interesse correspondem a produtividade da empresa (vendas sobre empregados) e a produtividade inovadora da empresa (vendas de produtos/serviços inovadoras sobre empregados), utiliza-se a distribuição normal da variância tipicamente usada como base para as estimativas (Liang e Zeger, 1986). Da mesma forma, a função link de identidade (*id*) é escolhida, cuja expressão para o padrão marginal é relativamente fácil de calcular ou se aproximar da função *link* padrão. A estimativa econométrica neste trabalho também considera a correlação não estruturada (*uns*). A matriz de correlação não estruturada é a estrutura mais geral das estruturas de correlação verificadas, dado que não impõe estrutura à matriz de correlação e é igual à matriz não estacionária para o atraso máximo (Hardin e Hilbe, 2012). A matriz de correlação de trabalho é especificada como R = α, onde alfa é definido pela equação:

$$\hat{\alpha} = \frac{\sum_{i=1}^{n} n_i}{\sum_{i=1}^{n}\sum_{t=1}^{n_i} \hat{r}_{i,t}^2 / n_i} G$$

De modo particular, a partir das especificações definidas no modelo, foi estimada a seguinte equação de forma reduzida:

$$y_{it} = \alpha + \beta_1 X_{1it} + \beta_2 X_{2it} + \beta_n X_{nit} + \ldots + \varepsilon_{it}$$

onde o subscrito *i* representa a dimensão empresa (*i*=1,..., n); o subscrito *t refere-se* a dimensão tempo (t=1,2,3,4); $Y_{it}$ indica a variável dependente; $\alpha$ captura a heterogeneidade da empresa não observável; $X_{it}$ indica as variáveis explanatórias; e $\varepsilon_{it}$ é o termo de erro residual que capta todos os demais efeitos. O estudo não adota uma estrutura de retardo no modelo, visto que não considera a associação direta entre a existência entre obstáculos e a produtividade da inovação e a produtividade da empresa, nos moldes do que poderia suceder em outras situações que abordam a inovação[3]. Finalmente, para fins de comparação, também foram executados modelos adicionais a configuração das variáveis com base nos pressupostos existentes na literatura. Conforme verificado, os resultados desses modelos não foram marcadamente diferentes do modelo central do GEE, garantindo confiança na robustez dos resultados para a escolha da técnica analítica utilizada.

O foco das variáveis dependentes empregadas está na produtividade laboral, um indicador de eficiência que em economia se utiliza para mensurar o esforço necessário para inserir produtos e serviços no mercado. Convencionalmente, a produtividade laboral tende a ser maior onde exista maior disponibilidade de capital, uma maior exploração da economia de escala, um maior uso de tecnologias mais avançadas ou onde os trabalhadores apresentam um nível maior de especialização. A produtividade da empresa é definida aqui sob dois parâmetros: (i) o resultado das vendas totais da organização sobre o trabalho, variável denominada de *ln_produtiv*; e (ii) o resultado das vendas oriundas de produtos e/ou serviços inovadores sobre o trabalho, variável etiquetada de *ln_produtiv_inov*. O *input* das vendas totais e das vendas inovadoras são obtidos e considerados em números monetários (pesos uruguaios). O *input* trabalho considera a quantidade de pessoas vinculadas à empresa em números absolutos. Para efeitos de análise, os grupos empresariais são considerados de forma desarticulada, sendo cada filial entendida de maneira individual. Assumindo estes parâmetros, calcula-se a função logarítmica natural $\ln v - \ln L = \ln\left(v/L\right)$, onde *v* representa as vendas totais ou as vendas originadas de produtos e serviços inovadores, e L representa o número total de empregados em cada organização.

### 3.2. VARIÁVEIS INDEPENDENTES

As variáveis explicativas se baseiam, fundamentalmente, nos efeitos da percepção dos obstáculos à inovação sobre a produtividade total e a produtividade inovadora da empresa. Para isso, os obstáculos são organizados por tópicos e reagrupados em quatro diferentes variáveis a

[3] Cabe destacar que a não aplicabilidade de retardo não se configura como estratégia isolada. Uma literatura anterior apresenta que o desfase entre gastos em P&D e depósitos de patentes não são verdadeiramente significativos (Hall et al., 1986). De forma complementar, pesquisas empíricas mais recentes se apoiam na visão de um processo contínuo de ciclos de vida mais curtos, de tempo reduzido do mercado para o desenvolvimento de novos produtos tendo em vista o aumento na participação nas vendas decorrentes destes (Lööf, 2005). Contudo, para o estudo em questão, não se pode deixar de considerar que o objeto retratado é o de um país pequeno e em vias desenvolvimento, e que os tempos na introdução da inovação pode apresentar suas diferenças com demais contextos. Da mesma forma, a perspectiva concomitante da produtividade da empresa, a partir da razão mais tradicional (vendas sobre empregos), desvincula-se mais fortemente da associação direta entre produtividade e obstáculos.

serem estimadas[4]: i) obstáculos de conhecimento (*obst_Conhe*$_{it}$); ii) obstáculos econômicos (*obst_Econo*$_{it}$); iii) obstáculos de mercado (*obst_Merca*$_{it}$); e iv) obstáculos institucionais (*obst_Insti*$_{it}$). Cada obstáculo reagrupado é inserido nos modelos como variável *dummy*, assumindo um valor de 1 se a empresa percebeu a dificuldade com importância "alta" ou "media"[5], e um valor de 0 caso contrário.

Além dos obstáculos à inovação, numerosos fatores mais podem manter relação com a performance económica da empresa e servir de referência para o modelo. Diante disso, foram incluídas cinco variáveis secundárias nos dados do painel relacionados a produtividade da organização ao longo do tempo, como o tamanho da empresa, o comportamento exportador, o nível educacional dos empregados, a idade da organização e a incidência de inovação de carácter organizacional no âmbito empresa.

A condição do tamanho da organização segue marcando consideravelmente a produtividade da empresa. As lacunas entre pequenas e grandes empresas podem ser atribuídas a uma série de fatores, seja diferenças na eficiência gerencial, preços mais elevados do capital em relação ao trabalho que dão origem a diferenças de capital por trabalhador, a economias de escala relacionada ao tamanho da planta ou a tempos de produção mais curtos (Baldwin et al., 2013). Ante a estas características, as diferenças nos estudos que relacionam produtividade e tamanho parece estar mais no enfoque das análises do que na confirmação da hipótese. Existe, por assim dizer, um maior consenso de que o tamanho está relacionado ao porte da empresa. Contudo, enquanto que resultados tendem a confirmação desta premissa (Godin e Clemens, 2007; Witmer e Zorn, 2007; Leung et al., 2008; Bloom et al., 2010), a densidade de resultados que mostram a relação entre produtividade inovadora e tamanho da empresa é ainda incipiente e levemente diferente. Empresas cujo tamanho da matriz no seja demasiado grande atingem maiores cotas de produtividade da inovação da mesma forma que as empresas *spin-off* de caráter tecnológico (Larrañeta et al., 2007; Díaz, et al., 2015). Contudo, a análise inclui a variável tamanho da empresa (*ln_tamanho*) para capturar a relação com a produtividade, que é convertida em uma função logarítmica natural segundo o número total de empregados da organização.

Resultados levantados ao nível da empresa a partir de uma série de estudos sobre a relação exportação e produtividade sugerem que as empresas exportadoras são mais produtivas que as não exportadoras. Por outro lado, enquanto que as empresas mais produtivas se auto

[4] A variável "obstáculos de conhecimento" é o resultado da agregação de quatro obstáculos ligados ao conhecimento: escassez de pessoal qualificado, rigidez organizacional, escassas possibilidades de cooperação com outras empresas/instituições, insuficiente informação sobre mercados e insuficiente informação sobre tecnologias. A variável "obstáculos econômicos" é o resultado da agregação de três barreiras relacionados a aspectos econômicos: riscos à inovação, período de retorno do investimento e dificuldades de acesso ao financiamento. A variável "obstáculos de mercado" é o resultado da agregação de duas barreiras relacionadas às características do mercado em que as empresas operam: reduzido tamanho do mercado e escassas oportunidades tecnológicas do setor a empresa pertence. Por último, a variável "obstáculos institucionais" é o resultado da agregação de quatros obstáculos vinculados a fatores institucionais: escasso desenvolvimento das ICTs, infraestrutura física inadequada, sistema de propriedade intelectual e deficiente instabilidade econômica.

[5] Em conformidade com outros autores (Hölzl e Janger, 2013; 2014), o valor 1 é assumido para "alta" e "média" importância, o que significa uma melhor distribuição dos resultados na estimação do modelo. No entanto, cabe destacar que o uso variável binário com valor 1 para "alta" importância, na prática, não apresenta diferenças significativas na estimação dos modelos.

selecionam nos mercados de exportação, parece não existir evidencias empíricas que demostra que a exportação melhora a produtividade (Wagner, 2007). Articulado a estes levantamentos e considerando a elevada heterogeneidade existente entre países, Kostevc (2005) já adiantava que o aumento da produtividade pode estar relacionado mais ao efeito causado pela expansão da escala do mercado num primeiro momento e menos a melhorias da produtividade permanente real. Nesse sentido, os modelos incluem uma variável *dummy* (*export*) para capturar esse aspecto, considerando um valor de 1 para empresas exportadoras e um valor de 0 para o contrário.

O papel do capital humano, de território a território, está aberto a diferentes interpretações, porém, basicamente, produzem-se evidencias empíricas que influem significativamente a produtividade. Griffith et al. (2004) são responsáveis por mapear as principais economias da OECD ao nível da indústria e concluírem que os efeitos do capital humano, conjuntamente com a P&D, são capazes de estimular não somente a produtividade como também a inovação e a capacidade absortiva. Neste caso, é interessante considerar que determinadas diferenciações nos resultados podem estar associadas à condição da fronteira tecnológica do país que se localiza a indústria. O retorno do investimento em capital humano ou P&D pode ser subestimado em economias como as dos Estados Unidos, na medida em que se encontram na fronteira da tecnologia para um número maior de indústrias e aparentemente podem apresentar um menor retorno social do investimento. Enquanto que em países com menor nível de desenvolvimento, um maior investimento nesse sentido pode representar um aumento mais significativo na taxa de produtividade. Portanto, os modelos incorporam a variável *dummy* (*alta_educ*) para verificar o papel da educação na produtividade. Essa variável assume um valor de 1 se a empresa possui empregados com ensino superior e um valor de 0 caso o contrário.

A relação entre produtividade e idade, por sua parte, apresenta um comportamento supostamente sensível de verificação. Apesar desta característica, a inclusão desta variável busca enriquecer a análise por entender que a longevidade da organização representa experiências e aprendizagens acumuladas que acabam sendo transversais a demais comportamentos relacionados a produtividade ou a inovação. A característica individual é complexa e multidimensional e, seguindo a revisão de Ilmakunnas et al. (2010), não é fixa e logicamente modifica-se ao longo do tempo. A experiência acumulada pode resultar benéfica através do desempenho dos trabalhadores no *learning-by-doing* (Lundvall e Johnson, 1994) e/ou no desenvolvimento do conhecimento tácito (Gray, 2006), por exemplo. No entanto, interpretando em termos biodinâmicos, o passar dos anos podem influir sobre aspectos físicos, psíquicos dos indivíduos ou produzir efeitos decorrentes de uma maior rigidez organizacional. Evidentemente que uma interpretação desse tipo apresenta riscos reducionistas, porém quando considerado a organização como um sistema composto de indivíduos e recursos, essa interação pode resultar em comportamentos dinâmicos de aprendizagem. À vista disso, a análise inseri uma variável logarítmica natural (*ln_idade*) com o intuito de obter a relação da idade da empresa com a produtividade.

Finalmente, a inovação organizacional é escolhida como variável de controle dada a sua função de complementariedade. Polder et al. (2010) identificam que este tipo de inovação organizacional alcança níveis mais elevados de produtividade e que os outros tipos de inovação – produtos e processos – representam uma produtividade mais significativa quanto realizadas em

combinação com uma inovação organizacional. A condição parece suceder em ambos os setores, embora projete efeitos mais representativos no setor de serviços. Em suma, os resultados dizem que a inovação organizacional possui um efeito positivo tanto sobre a produtividade isolada quanto contribui para capitalizar a produtividade da inovação de produto ou processo. Deste modo, os modelos incluem uma variável *dummy* (*inov_org*) para captar esse efeito, considerando um valor de 1 para empresas que realizam inovação organizacional e um valor de 0 para as demais.

Na próxima seção serão apresentados os principais resultados empíricos dos estimadores, acompanhados da discussão a respeito da relação entre as variáveis.

## 4. Resultados e discussão

As tabelas 2 apresenta as estimativas decorrentes da análise empírica e mostram que a importância entre os obstáculos e a produtividade obtida das vendas totais e a produtividade decorrente das vendas das inovações possui nuances explicativos. O modelo 1 é dedicado à interpretação da produtividade de maneira geral e o modelo 2 à respectiva produtividade da inovação na empresa.

Em relação às variáveis explanatórias, os modelos econométricos apresentam resultados de alguma forma contrapostos e que permitem uma verificação complementar. As empresas que percebem mais fortemente os obstáculos à inovação vinculados a fatores de conhecimento apresentam uma relação negativa e significativa com a produtividade da inovação. Por outro lado, o comportamento deste obstáculo ante a produtividade da empresa não assume resultados significativos. Estes resultados, em parte, são coerentes com o principal da literatura sobre obstáculos de conhecimento (Coad et al., 2016), e sugerem uma interpretação de caráter lógico. Em particular, um possível aumento na produtividade obtida da inovação parece estar mais sujeito aos efeitos desses fatores do que poderia resultar de um mercado mais maduro ou convencional, o que denota que produtos e serviços inovadores, devido a capacidade em alavancar margens mais dispares de produtividade, acabam sendo mais sensíveis as próprias dificuldades.

Um pequeno país em vias de desenvolvimento, como o que caracteriza a aplicação da análise, poderia estar encontrando dificuldades substancias em dispor de conhecimento necessário para realizar inovação em diversos aspectos, entre eles devido: a reduzida capacidade de adequar o sistema educacional às necessidades das empresas ou setores; a desterritorialização da população, principalmente das camadas mais jovens da sociedade. Cabe destacar que a problemática do capital humano se confirma empírica e teoricamente, conforme verificado em outros autores numa revisão da literatura (Griffith et al. (2004). Nos resultados obtidos, o elevado nível de educação denota essa relação positiva e fortemente significativa em ambas categorias que mensuram a produtividade. Adicionalmente, dificuldades em estabelecer cooperação com outros agentes técnico-científicos poderiam estar detrás da reduzida articulação destes ou da baixa capacidade tecnológica que os mesmos dispõem. Por outro lado, a rigidez organizacional oriunda de empresas mais tradicionais ou mais assentadas poderia explicar um comportamento de menor disponibilidade à mudança. Em função das dificuldades em obter informações sobre o mercado ou sobre a própria tecnologia, esta última poderia estar articulando-se mais fortemente e estar na raiz explicativa da reduzida capacidade dos fatores anteriormente citados. Contudo, cabe sublinhar que

não existe evidências tangíveis para um efeito de aprendizagem tangível, como foi possível verificar na literatura supracitada.

Tabela 2. Resultados da regressão das produtividades em empresas potencialmente inovadoras - Uruguai - 2001-2015[a]

| Variáveis Explanatórias | Produtividade empresa | | Produtividade inovação | |
|---|---|---|---|---|
| | Coef. | Erro padrão | Coef. | Erro padrão |
| obst_conhe | -0,015 | 0,022 | -0,019 ** | 0,009 |
| obst_econo | 0,010 | 0,021 | -0,027 *** | 0,009 |
| obst_merca | -0,074 *** | 0,022 | -0,026 *** | 0,009 |
| obst_insti | -0,037 | 0,022 | -0,031 *** | 0,010 |
| lntamanho | -0,003 | 0,008 | 0,029 *** | 0,003 |
| exporta | -0,062 *** | 0,020 | 0,023 *** | 0,008 |
| alta_educ | 0,299 *** | 0,066 | 0,538 *** | 0,034 |
| lnidade | -0,616 *** | 0,110 | -0,076 ** | 0,038 |
| inov_org | 0,042 ** | 0,020 | 0,029 *** | 0,010 |
| _cons | 2,541 *** | 0,049 | 2,216 *** | 0,019 |
| | | | | |
| Nº total de observações | 3.098 | | 1.022 | |
| Wald chi2 | 117,56 | | 481,94 | |

*Notas:* [a]Correlação não estruturada; Link: identidade; Family: normal; Teste significância: * p < 0,10, ** p < 0,05, *** p < 0,01.
*Fonte:* Elaboração própria a partir dos dados da ANII (2005; 2008; 2012; 2014; 2017).

A dificuldades econômicas assumem uma função importante na literatura empírica sobre os obstáculos, orientando uma parte substancial das análises realizadas (Beck et al., 2006; Tiwari et al., 2008; Hottenrott e Peters, 2012; Coluzzi et al. 2015; Coad et al., 2016). De forma análoga a categoria anterior, os obstáculos econômicos demostram uma relação não estatisticamente significativa.com a produtividade em geral, enquanto que a sua relação com a produtividade da inovação é altamente significativa e negativa. Mais além dessa relação negativa, subordinada a produtos e serviços inovadores, a falta de significância das dificuldades econômicas com a produtividade tradicional assinalaria indícios para uma prática inovadora de importância menor. Os fatores econômicos, dessa forma, parecem acabar sendo desinflados enquanto percepção, dada a incapacidade de trasladarem efeitos substancias à relação entre venda e quantidade de trabalhadores necessários para subministrar o mercado, o que por outra parte sinaliza novamente o distanciamento existente entre ambas categorias de produtos ou serviços inovadores e não inovadores. Em uma relação negativa com produtividade da inovação, esse tipo de comportamento pode ser alusivo a dificuldades reais na obtenção de financiamento, uma maior percepção do risco ao inovar, ou mesmo de que o retorno dos investimentos realizados para a implementação da inovação, no final das contas, seja tido como insuficiente, não repercutindo na produtividade da organização.

Modificando, em parte, a sequência anterior, os obstáculos de mercado associam-se duplamente às produtividades investigadas: paras ambas variáveis a relação é negativa e altamente significativa. É a primeira e única vez que a produtividade da empresa demostra relação com algum dos fatores, demonstrando que as dificuldades de mercado dispõem de maior transversalidade na performance econômica da empresa do que nas demais barreiras. São diversas as razões possíveis de explicação, em particular o fato de as empresas serem influenciadas pelo pequeno mercado que representa o País ou o caráter ainda pouco articulado do Mercosul. A variável sobre exportação resulta em um indicador útil para uma verificação nesse sentido ao sinalizar a importância que tem o mercado externo dos pequenos países para qualificar a sua produtividade. No entanto, cabe destacar que a variável dependente produtividade da inovação mantem relação fortemente significativa e positiva com a condição exportadora, enquanto que para a produtividade da empresa não é significativa. A variável exportação, assim, sugere que a produtividade se vê mais condicionada às dificuldades em realizar produtos e/ou serviços inovadores orientados ao mercado externo, o que numa perspectiva do desenvolvimento da estrutura econômica nacional, essas dificuldades poderiam estar sendo influenciadas pelas escassas oportunidades no setor de pertencimento da empresa no âmbito interno. Em contrapartida, apesar de estar condicionadas a fatores de mercado no que corresponde ao mercado interno, a produtividade da empresa parece não estar diretamente relacionada quando se trata dos produtos e/ou serviços de exportação.

Por último, os obstáculos de caráter institucional reproduzem o comportamento da maioria dos obstáculos. Indicam uma relação não significativa com a primeira variável de produtividade, enquanto que é altamente significativa e negativa para a segunda. As dificuldades institucionais à inovação, nesse sentido, podem ser menos importantes em um cenário mais fortemente caracterizado por receitas obtidas de produtos ou serviços mais convencionais, cuja institucionalidade está assentada em prerrogativas orientadas a este tipo de atividades. Por outro lado, a forte relação existente entre os fatores institucionais e a produtividade da inovação por si só satisfaria a acepção de um sistema estrutural (econômico, regulatório, científico-tecnológico, etc.) menos amigável à implementação da inovação e, consequentemente menos favorável ao aperfeiçoamento desta performance econômica da empresa.

Em relação às demais variáveis específicas da empresa, o tamanho afeta significativamente a produtividade da inovação, porém não apresenta relação significativa com a produtividade da empresa. Como discutido anteriormente, o consenso na relação entre tamanho e produtividade é ainda relativamente incipiente e levemente diferente (Godin e Clemens, 2007; Witmer e Zorn, 2007; Larrañeta et al., 2007; Leung et al., 2008; Bloom et al., 2010; Díaz et al., 2015). Diante disso, os resultados encontrados poderiam sugerir que a relação positiva com a produtividade da inovação esteja vinculada a existência de uma estrutura organizacional mais consolidada em termos de inovação, isto é, que possivelmente logram implementar mais ou mais eficientemente novos produtos ou serviços a partir da estrutura e recursos disponíveis, enquanto que para produtos ou serviços convencionais esta mesma lógica não seria diretamente transponível. Em compensação, a variável idade, que na literatura parece ser ainda mais controversa, esta indica uma relação negativa com ambas variáveis dependentes, sendo mais fortemente significativa com a produtividade gerada a partir de produtos e/ou serviços mais convencionais. Os resultados sugerem que empresas mais jovens podem apresentar características

mais flexíveis do que as maduras e, dispondo de menores recursos disponíveis para investir e/ou sendo mais sensíveis aos custos ou riscos assumidos pela inovação, tendem a ser levemente mais produtivas em mercados mais convencionais.

Em consonância com outros autores (Poder et al., 2010), este exercício permite checar que a inovação organizacional resulta numa variável também efetiva para interpretar o aumento em ambas produtividades (decorrentes das respectivas funções produtivas). Os resultados de Poder et al. (2010), cujos pressupostos sinalizam também para um aumento da produtividade quando outras inovações (produto/serviço) se vissem associadas a inovação organizacional, permite ir um passo mais adiante na explicação. A inovação organizacional, nesse sentido, seria válida para produtividade mesmo e quando esse aumento na produtividade não decorresse do faturamento de produtos e/ou serviços inovadores. Apesar desta variável assumir uma função de controle, situa-se aqui a possibilidade de ser mais fielmente verificada numa tentativa entender a relação que estabelece com os obstáculos e o fenômeno de aprendizagem que pode estar facilitando a superação destas dificuldades e o subsequente incremento da produtividade.

Estudos anteriores sobre os obstáculos à inovação apontaram para um efeito da aprendizagem, quando a capacidade em realizar atividades inovadores estava diametralmente alinhada a existência de obstáculos (p.ex., D'Este et al., 2012). Os resultados de Coad et al. (2016), mesmo que parcialmente e restritos a um fator específico, sinalizaram também para este sentido. Portanto, a ideia de um possível efeito de aprendizagem adquirido através da maior percepção dos obstáculos parece não se trasladar aqui à produtividade, em particular quanto aos obstáculos de mercado (na relação com o mercado interno) que assumem um comportamento estanco, de relação negativa. Entretanto, as categorias adjacentes poderiam estar entrelaçando-se e servindo de base para uma produção desse efeito, porém até este instante ficariam relegadas a aprofundamentos futuros.

## 5. Conclusões

Este estudo procurou preencher uma lacuna no entendimento sobre os efeitos dos obstáculos à inovação na performance económica da empresa. Para isso, foram estimados regressores de obstáculos ante a duas diferentes definições de produtividade considerando o conjunto de empresas potencialmente inovadoras do Uruguai a partir dos dados da ENII para o período 2001-2015.

A vinculação dos efeitos dos obstáculos à inovação sobre a produtividade buscou responder a uma das linhas presentes na literatura empírica que estabelece a relação destes com uma variável efetiva. Em contraposição ao debate de maior predominância, que tendem a explicitar os fatores explicativos às dificuldades das empresas em realizar inovações, este trabalho discorreu sobre uma configuração ainda sensível, porém de profícuos resultados ao conjunto da bibliografia existente e de importância sumária para a soma dos resultados disponíveis neste pequeno país latino-americano. O uso da percepção dos obstáculos para a análise da produtividade reduzida ao nível micro, destoando dos estudos mais tradicionais sobre a performance económica (Crépon et al., 1998; Griffith et al., 2004, 2006; OCDE, 2009; Mairesse e Mohnen, 2010; Mohnen e Hall, 2013),

consistiu em circunstancia explicativa pregressa à própria realização ou implementação da inovação.

Os resultados revelam existir uma certa homogeneidade interna em relação a cada uma das produtividades levantadas nas empresas uruguaias. Os quatro tipos de obstáculos à inovação considerados apresentaram relação negativa com a produtividade gerada através das vendas de produtos e serviços inovadores. Por outro lado, a maioria das dificuldades não mostraram relação significativa com a produtividade de produtos mais convencionais. A única exceção à regra derivou dos fatores de mercado, que apresentaram relação negativa e altamente significativa com ambas produtividades (total e inovadora).

Uma das principais conclusões deste estudo corresponde ao fato de os obstáculos à inovação exercerem maior interferência à produtividade resultante dos produtos e/ou serviços inovadores. Nesse contexto parece prevalecer a proporcionalidade que representa produtos e/ou serviços mais convencionais para produtividade geral da empresa, cuja percepção das barreiras à inovação tendem a conferi-la efeitos basicamente inócuos. No entanto é pertinente verificar que no conjunto das dificuldades, os fatores de mercados assumiram uma importância significativa em relação a proporcionalidade da produtividade da empresa, o que sugere que problemas relacionados ao mercado acabam refletindo se não em efeitos propriamente ditos, na importância que as empresas conferem a eles também em um mercado mais convencional. Em outros termos, é correto afirmar que os fatores de mercado acabam sendo transversais na relação entre ambos tipos de produtividade.

Além disso, as empresas maiores e responsáveis por produtos e/ou serviços inovadores sinalizaram maiores índices de produtividade. Porém, o tamanho da organização não resultou ser significativo com a função de produtividade mais tradicional. A exportação, condição teoricamente crucial para pequenos mercados, mostrou estar relacionada com a produtividade inovadora, enquanto que não contribuiu para elevar a produtividade de produtos e/ou serviços da empresa em geral. A produtividade sugere não estar sujeita às dificuldades em realizar produtos mais tradicionais, orientadas ao mercado externo, apesar de sofrerem das mesmas dificuldades de mercado para realizar inovação quando orientada ao mercado interno. Visto de outra forma, os obstáculos de mercado não somente prejudicam a produtividade de produtos inovadores, como também afetam a produtividade da empresa como um todo quando considerado o mercado nacional. A educação mais elevada, por sua vez, representou ser positiva para elevar ambas produtividades. Contudo, a importância do capital humano qualificado tende a ser mais crucial para a produtividade da inovação, que se demonstrou afetada pelos obstáculos de conhecimento. Em contrapartida, as empresas em idade mais avançada resultaram menos produtivas que as mais jovens, com uma maior significância em empresas orientadas a produtos e/ou serviços mais convencionais. Finalmente, a inovação organizacional, que em resultados anteriores sinalizaram favorecer um aumento da produtividade quando associada a demais inovações (Poder et al., 2010), neste caso parece contribuir para os elevar ganhos também da produtividade geral.

De forma geral, os resultados encontrados sustentam interpretações que corroboram para o desenvolvimento de políticas públicas no âmbito da inovação. Usufruindo-se, de forma complementaria, de achados levantados em outros estudos, essas políticas necessitam considerar as especificidades identificadas nos dois tipos de produtividade em um pequeno país em

desenvolvimento. Em particular, tais políticas devem ser capazes de reconhecer e coordenar ações que possibilitem minimizar os efeitos de todos os obstáculos à inovação, com especial interesse aos fatores de mercado que parecem prejudicar a produtividade tanto dos produtos e/ou serviços inovadores como daqueles mais convencionais. Entre outras medidas, as políticas devem ser capazes qualificar a formação e acesso de pessoal qualificado às essas empresas, além de desenvolver medidas que incentivem a exportação de produtos e serviços inovadores, uma vez que estas demonstram dispor de especial participação em elevar os índices de produtividade.

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## ANEXO

Tabela A.1. Acrônimos e definições do conjunto de variáveis

| Acrônimos | Definições |
|---|---|
| Ln(produtividade geral) | Log. da razão entre vendas e número de empregados |
| Ln(produtividade da inovação) | Log. da razão entre vendas inovadoras e número de empregados |
| Obstáculos de conhecimento | *Dummy* = 1 se a empresa considerou os obstáculos de conhecimento com média ou alta importância; 0 caso contrário |
| Obstáculos econômicos | *Dummy* = 1 se a empresa considerou os obstáculos econômicos com média ou alta importância; 0 caso contrário |
| Obstáculos de mercado | *Dummy* = 1 se a empresa considerou os obstáculos de mercado com média ou alta importância; 0 caso contrário |
| Obstáculos institucionais | *Dummy* = 1 se a empresa considerou os obstáculos de institucionais com média ou alta importância; 0 caso contrário |
| Ln(tamanho) | Log. do número total de empregados da empresa |
| Exportação | *Dummy* = 1 se a empresa comercializou externamente nos últimos 3 anos; 0 caso contrário |
| Educação superior | *Dummy* = 1 se a empresa teve pelo menos um empregado com ensino superior; 0 caso contrário |
| Ln(idade) | Log. da idade da empresa (calculado os anos decorridos desde a sua fundação) |
| Inovação organizacional | *Dummy* = 1 se a empresa realizou pelo menos uma inovação organizacional nos últimos 3 anos; 0 caso contrário |

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## 5.3 E3. The impact of research output by fields of science on economic growth: do human capital and structural change matter? - Aurora Teixeira, Tânia Pinto

**THE IMPACT OF RESEARCH OUTPUT BY FIELDS OF SCIENCE ON ECONOMIC GROWTH: DO HUMAN CAPITAL AND STRUCTURAL CHANGE MATTER?**

**EL IMPACTO DEL OUTPUT CIENTÍFICO, POR ÁREAS CIENTÍFICAS, S EN EL CRECIMIENTO ECONÓMICO: ¿SERÁ EL CAPITAL HUMANO Y EL CAMBIO ESTRUCTURAL RELEVANTES?**

**O IMPACTO DO OUTPUT CIENTÍFICO, POR ÁREAS CIENTÍFICA,S NO CRESCIMENTO ECONÓMICO: SERÃO O CAPITAL HUMANO E A MUDANÇA ESTRUTURAL RELEVANTES?**

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ABSTRACT

Whether research output significantly impacts on economic growth, and which research areas/ fields of science matter the most for increasing countries' economic performance, stand as fundamental endeavor of scientific inquiry. Extant literature analyses the impact of the research output on economic growth mainly in global terms, overlooking the impact of given fields of research. In order to fill in this gap, the present study resorts to panel data estimations based on a sample of 65 countries over 36 years (1980 to 2016). We evidence that research output is a critical determinant of economic, with some areas, such as 'Arts and Humanities' and 'Engineering and Technology', contributing in a larger extent to countries' economic growth. The direct effect of human capital emerged also as an important lever of growth but not structural change. The impact of research output is not dependent on countries' human capital levels or structural change. Therefore, the amount of scientific output *per se*, particularly in 'Arts and Humanities', is likely to promote economic growth.

*Keywords:* Research output; human capital, structural change, economic growth; bootstrap panel data estimation.

RESUMO

Se o output científico é significativo ou não, e quais as áreas científicas mais relevantes para o crescimento económico, constitui um importante assunto ao nivel de cada país. A literatura existente analisa o impacto do resultado do output científico sobre o crescimento económico, sobretudo em termos globais, tendo até à data negligenciado a análise do impacto de determinadas áreas de investigação. A fim de preencher esta lacuna, o presente estudo recorre a estimativas de dados em painel com base em uma amostra de 65 países ao longo de 36 anos (1980 a 2016). Evidenciamos que o output científico é uma

determinante crítica do crescimento económico, com algumas áreas científicas, como "Artes e Humanidades" e "Engenharia e Tecnologia", contribuindo em maior medida para o crescimento económico dos países. O efeito direto do capital humano emergiu também como uma importante alavanca de crescimento, mas não a mudança estrutural. O impacto do output científico não depende dos níveis de capital humano ou das mudanças estruturais dos países. Portanto, a quantidade de produção científica per se, particularmente em 'Artes e Humanidades', tende a promover o crescimento económico.

*Palavras-chave:* Produção científica; capital humano, mudança estrutural, crescimento económico; dados do painel com bootstrap.

Scientific area according to the congress list: Innovation and technological development in the world economy

Is it candidate to the **José Luís Sampedro Prize/Award**? Sim

## 1. INTRODUCTION

Knowledge accumulation is fundamental for economic growth (Vinkler, 2008; Inglesi-Lotz and Pouris, 2013; Nutli *et al*., 2015). To the extent that scientific research creates new knowledge (Inglesi-Lotz and Pouris, 2013), being a source of innovation that can improve human capital, it can lead to enhancements on the productive capacity and labor quality which are conducive to economic growth (Nutli *et al*., 2015; Hatemi-J *et al*., 2016).

The impact of research output on economic growth is thus very important for policy purposes (Lee *et al*., 2011; Inglesi-Lotz and Pouris, 2013). Consequently, whether the research output significantly impacts on economic growth, and which research areas/ fields of science matter the most for increasing economic performance, stand as fundamental endeavor of scientific inquiry.

Extant literature analyzes the impact of the research output on economic growth mainly in global terms (see Vinkler, 2008; Inglesi-Lotz *et al*., 2015; Ntuli *et al*., 2015; Hatemi-J *et al*. 2016; Solarin and Yen, 2016), that is, without discriminating research output by fields of research. Very few studies analyzed the impact of given fields of research on economic growth. The exceptions include the analysis of the impact of biotechnology research output on Turkish economic growth, 1981-2013 (Yasgul and Guris, 2016), chemical engineering on the growth of a small set of countries (Australia, Canada, Great Britain, India, and the U.S.) over almost 30 years (1970-1996) (Hart and Sommerfeld, 1998), and the impact of individual fields of science, such as biology and biochemistry, chemistry, material sciences, physics, psychiatry and psychology on South Africa's growth between the period 1980-2008 (Inglesi-Lotz and Pouris, 2013). These studies found a positive and significant impact of the research output on economic growth.

To the best of our knowledge, no study has yet analyzed the impact of research output on economic growth in a large set of countries considering, in simultaneous, a wide variety of fields of research (e.g., arts, engineering, health,

humanities, life sciences). The analysis of distinct fields of research would allow to understand whether there are different growth impacts depending on the area of research, and which areas of research might conduct to higher economic growth.

Moreover, given that this impact is likely to be intermediate by countries' human capital endowments and productive specialization (Wolff, 1999; Fagerberg, 2000; Tsvetkova *et al*., 2017), to understand which types of research are aligned with countries' absorptive capacity and pace of structural change is crucial from a scientific and policy makers' view point. Indeed, human capital and structural change, two important engines of economic growth (Hanushek and WoBmann, 2012; Aisen and Veiga, 2013; Teixeira and Queirós, 2016), might interact with research output to enhance or diminish the global impact of research output on growth. Such impacts were not yet empirically tested.

Thus, resorting to panel data of 65 countries over the period of 1980 to 2016, we resort to random effects panel data estimation with bootstrap.

The present paper is organized as follows. Section 2 summarizes the relevant literature. Section 3 defines and discusses the methodology. The empirical results are detailed in Section 4. Finally, the Conclusions put forward the main contributions, limitations, and policy implications of the present study.

## 2. LITERATURE REVIEW ON THE EFFECT OF THE RESEARCH OUTPUT ON THE ECONOMIC GROWTH: MAIN HYPOTHESES TO BE TESTED

The idea that the accumulation of knowledge has a central role in economic growth in the twenty-first century it is not new (Bosworth *et al*., 2002; Bhullar *et al*., 2014; Evans 2010). Its early treatment appears in Adam Smith's *Wealth of Nations* (Quatraro, 2010), where it is referred the new specialists that make important contributions to the production of economically useful knowledge. Although the subsequent development of the theory of capital accumulation by Adam Smith and the Physiocrats focused mostly on physical capital rather than on knowledge, Adam Smith recognized the critical importance of this latter factor (Prendergast 2010). Then, based on Adam Smith, Alfred Marshall proposed a

systemic account to incorporate knowledge in production process (Quatraro, 2010).

When referring to innovation as a major determinant of the economic growth, Schumpeter (1912 and 1942) identified knowledge as a step stone to achieve innovation. This idea was followed by the modern Schumpeterian such as Galbraith, Goodwin and Hirschman (OCDE, 1996). The Schumpeterian growth approaches view knowledge accumulation and its diffusion as central pieces of economic growth (Aghion et al., 2000). According to Schumpeterian perspectives, new knowledge associated to radical innovation contributes positive and significantly to economic development (Saviotti and Pyka 2004). Specifically, the creation of new knowledge and introduction of innovation are the result of the recombination of the existing knowledge (Antonelli, 2009, 2017). The generation of knowledge occurs as a result of efforts and actions of individual and characteristics of the system, i.e., organized complexity and knowledge connectivity (Antonelli and Link, 2015).

The scientific recognition of knowledge centrality in economics is recent (Romer, 1986; Lucas, 1988; Schumpeter 2000; Fedderke, 2006). The relationship between knowledge and economic growth can be formally explained by mainstream economic theories, the neoclassical and the endogenous growth theories (or New Growth Theory) (Solarin and Yen, 2016). In the first theory, knowledge associated to technology is exogenous, emerging as ‘manna from heaven’ (Solow 1956). In the New Growth Theory knowledge is considered as an input being endogenously produced through Research and Development (R&D) incentives (Romer, 1986). Thus, the investment in R&D contributes to an increase in the economic growth (OCDE, 1996).

Outside of the mainstream, there are some additional explanations for the nexus between knowledge and economic growth are put forward by the evolutionary and structuralist approaches. Evolutionary approach introduced a mechanism of productive diversification that according to Gabardo *et al*. (2017) can be interpreted as knowledge. Knowledge is considered a complex variable which cannot be analyzed in purely economic terms. Instead, knowledge is considered interactive and systemic and not only simply the result of individual learning (Castellacci, 2006). The modern evolutionary economics is related to the works

of Dosi (1982), Freeman *et al*., (1982), Nelson and Winter (1982) focus on the role of technical change in economic development considering that economic systems are out of equilibrium (Maurseth, 2001). According to the structuralist approach, economic development occurs when there are changes in the productive structure of the economy, which are intimately related to technological and scientific knowledge (Missio *et al*., 2015).

Knowledge can be materialized in research publications, books, and through physical and human capital (Hatemi-J *et al*., 2016). Thus, research activity can be an important measure of knowledge development (Fedderke and Schirmer 2006).

The scientific research output is one of the channels that creates new knowledge (Inglezi-Lotz and Pouris, 2013; Yasgul and Guris, 2016), most notably codified knowledge associated to scientific publications (Inglezi-Lotz and Pouris, 2013; Kumar et al., 2016; Solarin and Yen, 2016). Such knowledge is likely to induce positive externalities on economic productive capacity, as well as increased labor quality of labor, able to generate new products, services, processes and business models; summing up, to generate innovate and, ultimately, conduct to economic growth (Inglezi-Lotz *et al*., 2014; Inglezi-Lotz *et al*., 2015). Additionality, the volume of the research activities shows the capacities of a country's labor force and the attractiveness of the economy in terms of foreign and domestic investments (Kumar *et al*., 2016).

Empirically, some authors (Price, 1978; Kealey, 1996; King, 2004) found a linear or exponential relationship between economic performance and the number of research articles published. Accordingly, the scientific research creates new knowledge, being a source of innovation that can improve human capital (Ntuli *et al*. 2015). Consequently, it can lead to improvements on the productive capacity and on the labor quality of a country. All these factors are conducive to an increase in countries' economic growth (Nutli *et al*. 2015).

The impact of aggregate research output on economic growth has been explored by an already voluminous empirical literature (Lee *et al*., 2011, Inglesi-Lotz and Pouris, 2014; Inglesi-Lotz *et al*., 2015; Ntuli *et al*., 2015; Hatemi-J *et al*., 2016; Kumar *et al*., 2016 and Solarin and Yen, 2016). Such literature has identified

causality running from research output to economic growth, others from economic growth to research output, and others causality running in both directions.

Resorting to larger samples of countries, Solarin and Yen (2016) analyzed 169 countries and found that causality run, in general, from research output to economic growth. The same result was obtained for Finland, Hungary, México (Nutli *et al*., 2015), the UK (Hatemi-J *et al.*, 2016), and US (Nutli *et al*., 2015; Inglesi-Lotz *et al*. 2014).

The inverse causality, from economic growth to research output, was found by Ntutli *et al*. (2015) for Canada, France, Italy, New Zealand, UK, Austria, Israel, and Poland, whereas Kumar *et al*. (2016) uncover a similar result for the US.

Lee *et al*. (2011) found much clear evidence of the mutual causality in Asia than in Western countries, mentioning that highly developed countries that relationship is weaker. Focusing on the BRICS countries (Brazil, Russia, India, China, and South Africa), Inglezi *et al*. (2015) found mutual causality between research output and economic growth only in the Indian case, whereas Kumar *et al*. (2016) found mutual causality for China.

In spite of the debate about the direction of the relationship, we conjecture that, for broader samples of countries,

> *H1a: The overall research output impacts positively on countries' economic growth.*

Governments should have the capacity of prioritizing the areas of research according to the economic goals they have in mind (Ginbson and Hazelkorn, 2017). Indeed, different areas of the research – e.g. Arts & Humanities, Clinical, Pre-Clinical & Health, Engineering & Technology, Life Sciences, Physical Sciences, Social Sciences - have their own importance and can contribute to countries' economic growth in different ways (Lee *et al*., 2011) and each of the country has its own research strengths (King, 2004).

No theoretical account exists on how other different scientific areas might distinctively contribute to countries' economic growth. However, some empirical evidence suggest that they are critical for countries' economic growth and

development (see Yasgul and Guris, 2016; Jin, 2010 and 2009; Hart and Sommerfeld, 1998).

Regarding Social Sciences, scientific research can provide general but useful knowledge to policymakers, governments, organizations, and the society as a whole (Economic and Social Research Council, 2018).

Although the contribution of the scientific research on Arts and Humanities to social and economic progress has been in general overlooked, Benneworth (2015) suggests that such research leads to the creation of value by applying the wider model of research valorization in which its contributions can be translated in to the society by its impact on first-order users and the creation of social improvements. Additionally, according to The Arts and Humanities Research Council (AHRC, 2009),[1] Arts and Humanities research has significantly contributed to the innovation, creation and success of different sectors of activity. More recently, Munro (2016) and Comunian *et al*., (2014) highlight the relevance of Arts and Humanities research for the creative economy, through knowledge exchange activities. Besides their contribution to the "creative industries", Ginbson and Hazelkorn (2017) argue that Arts and Humanities research also contribute to civil society as a whole and, specially, the industry.

Physical Sciences research can be applied on economic inputs such as labor, capital and systems (Australian Academy of Science, 2015). Therefore, it might entail improvements in a myriad of areas, most notably public health, economic development and growth (WHO, 2005). Jaffe *et al*. (2013) found that countries with higher relative productivity in basic sciences, as physics and chemistry, grow faster. Moreover, these authors demonstrate that middle income countries that invest in basic sciences tend to growth faster than those that invest on applied research knowledge.

Life Science is considered as one of the most important areas of research for the future competitiveness of countries and firms (Thuermer, 2017; Bluestone and Clayton-Matthews, 2013; Waxell, 2011). Life Science scientific contributions encompass new therapies and medical technological, and agriculture, environment and industrial manufacturing applications (Howson and Davies,

[1] In https://ahrc.ukri.org/newsevents/publications/, last accessed on 09/09/2018.

2018; Hosang, 2014; Austrian Research and Technology Report, 2010). For instance, it has been establishing some strategies by the governments to promote the interaction between Life Science research with the Industry and consequently, with impact on economic growth (Austrian Research and Technology Report, 2018) and also the interaction of their subcategories, as example, biotechnology (Buchholz and Collins, 2013; Aguilar, et al. 2009). One of the subcategories of Life Science research, the Biotechnology research was found to have a positive and significant impact on Turkey's economic growth over the period 1981-2013 (Yasgul and Guris, 2016). According to Yasgul and Guris (2016), in spite of the biotechnology research is dependent on basic research (e.g., microbiology, biochemistry, genetics and bioengineering) and the process of transferring and commercialization of the basic research to the industrial sectors is highly uncertain, as it has the potential for being applied in various fields/sectors, from high to low tech or traditional sectors, its growth potential is substantial.

Respecting Clinical, Pre-Clinical and Health research, there is also some evidence that it has an important impact on economic growth. In concrete, resorting to a meta-analysis exercise, Roback et al. (2011) found that the socio-economic benefits of Health research exceed its socio-economic costs.

At a more applied perspective, it is important to acknowledge that the link between research and competitiveness has underlying the emergence, more than 20 years ago, of the engineering research centers' which sought to bridge government, university and industry (Roessner *et al*., 2010), and ultimately to increase the competitiveness of the firms, and consequently, economic growth. Indeed, The Centre for Economics and Business Research from the Royal Academy of Engineering (RAE) (Cebr, 2016) shows, resorting to an analysis of 99 countries, that the Engineering and Technology research area has a key role in growth and development of a country, by contributing to understand problems, find innovative solutions, services and goods. Regarding Chemical engineering, one of the subareas of Engineering and Technology, of utmost importance for countries' technical effort, Hart and Sommerfeld (1998), analyzing the United States, Canada, Great Britain, India and Australia, found a strong dependence of

these countries' economic growth on the volume of the publication in chemical engineering area, over the period 1970 to 1996.

At the empirical level, extant studies which address the relation between research output and economic growth does not explore the impact of distinct fields of the research. Additionally, the very few studies which analyzed the impact of given fields of research on economic growth tend to focus on one or few research areas without comparing the magnitude of their relative impacts (see Table A1 in Annex).

Focusing on a single research area, Biotechnology, Yasgul and Guris (2016) showed that the scientific output of this research field impacted significantly and positive on Turkey's economic growth. Also referring one research field, Chemical Engineering, Hart and Sommerfeld (1998) found a strong positive correlation between its scientific output and economic growth of all the countries in analysis (United States, Canada, Great Britain, India and Australia). Including several research fields in their analysis, for a sample of 46 countries between 1975 to 2003, Jin and Jin (2013) evidenced that, in general, causality went from research output of Science and Engineering, Science and Nature, Business Education, and Economics to economic growth. A similar result was found by Inglesi-Lotz and Pouris (2013) who concluded that research output of Biology and Biochemistry, Chemistry, Material Sciences, Physics, Psychiatry and Psychology positively impacted on South Africa's economic growth.

Summing up, each area of the research has their own importance and contribution for economic growth. Generally, the effect of the broad areas of the research tend to be positive on economic growth, but no theoretical arguments exist that allows us directly to assess the size of the impact of each area of research on the economic growth. From the previous exposition, we can infer that some areas of research (e.g., Social Science, Arts & Humanities, Clinical, Physical Sciences, Life Sciences and Pre-Clinical & Health) can contribute in a more general and encompassing way to economic growth, being useful for a wider set of industries and/or activities. Other areas, such as Engineering and Technology, have a more restricted contribution to economic growth.

Consequently, the contribution of these latter areas is likely to be smaller when compared with broader areas of research.

Based on the above, we conjecture that:

> *H1b: The research output from distinct fields impacts positively but with different magnitude on countries' economic growth.*

An economy characterized by high levels of human capital (education/ training) tend to be more productive and innovative (Mankiw *et al*., 1992; WoBmann, 2003; Bomann and Le, 2013), leveraging countries' economic growth (Jin, 2009; Jin and Jin, 2013).

The theoretical models of human capital (Schultz, 1961, Becker, 1962; Mincer, 1958) referred that the investment in the knowledge and skills in human capital can directly lead to increase in productivity and, consequently, raise economic growth. Human capital in particular, has a direct effect on the economy as more education lead to productivity improvements, enables the attraction of new technology from the highly advanced neighbor countries (Nelson and Phelps, 1966; Benhabib e Spiegel, 1994), fosters the creation of new products (Romer 1990, Benhabib e Spiegel, 1994), and thus stimulates countries' economic growth.

Empirically, a vast number of studies found a positive effect of human capital on economic growth (e.g., Barro, 1991; Mankiw et al.,1992; Krueger and Lindhal, 2001; Pritchett, 2001; Hanushek and Woessmann, 2008; Teixeira and Fortuna 2011; Goldin, 2016; Teixeira and Queirós, 2016; Kostoc and Gallo, 2018).

Thus, we conjecture that

> *H2: Human capital directly impacts on economic growth.*

Structural change, considered as a change of an economy's productive structure (Quatraro, 2010), is considered as an important determinant of the economic growth (Silva and Teixeira, 2011). The models which establish a relationship

between structural change and economic growth are relatively recent in the literature (see Montobbio, 2002; Saviotti and Pyka, 2004; Ciarli *et al*., 2010).

As an opposition of the traditional equilibrium of economic theories, the evolutionary and structuralist approaches emphasize the processes of structural changes (Śledzik, 2015) by introducing the mechanism of diversification (Gabardo *et al*., 2017), and highlighting the coevolution of demand and innovation (Metcalfe *et al*., 2006). The structuralist approach defends that economic growth can result from a specialization towards the industry in detriment of agriculture activities (Gabardo *et al*., 2017).

Empirically, studies that evaluated the impact of structural change on economic growth (e.g., Fagerberg, 2000; Timmer and Szirmai, 2000; Peneder, 2003; Wang and Szirmai, 2008) concluded that we can have a higher productivity when we move from primary sector, based on agriculture, to secondary factor, based on industry. Therefore, a higher level of productivity has a positive impact on economic growth.

From the above it is conjectured that:

> *H3: Structural change towards an increased importance of the industry impacts positively on economic growth*

Human capital might interact with research output because it operates as a productivity booster of research and development activities that underlie the research output (Silva and Teixeira, 2011). Thus, it is likely that countries with higher level of human capital obtain higher returns from scientific research activity. In other words, individuals with a higher level of human capital are likely to be more efficient in performing R&D activities, which results in higher levels of research output/ knowledge (Romer, 1990; Teixeira and Fortuna 2011; Bodman and Lee, 2013).

From the above it is conjectured that:

> *H4: Human capital indirectly, via research output, impacts on economic growth*

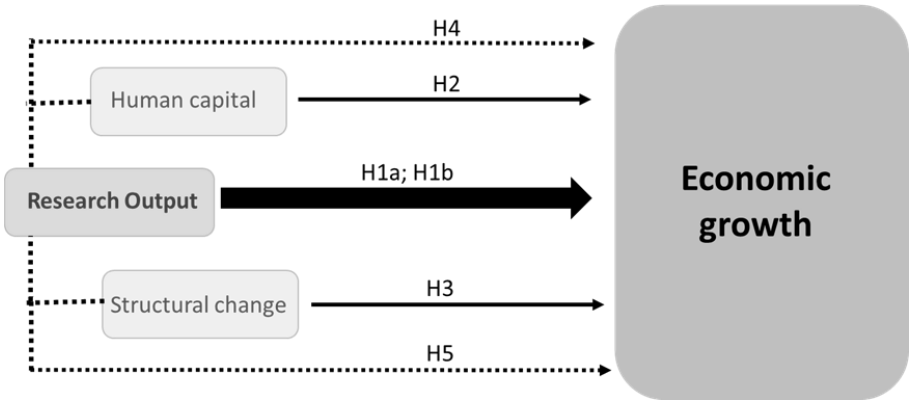
Structural change is of paramount importance for economic growth both directly (Frantzen, 2000; Wolff, 2003; Quatraro, 2009; Quatraro, 2010) and indirectly through the production of new knowledge (research output). In concrete, the matching between the change in productive structure (that is, the weight of a given sector in total employment and/or output) and the evolution of research output by scientific areas is likely to enhance the direct impact of the research output on economic growth (Quatraro, 2010; Silva and Teixeira, 2011). This occurs when the change in productive structure matches its specialization in research output (Silva and Teixeira, 2011). For example, a country that observes its productive structure changing in favor of life sciences industries might tend to grow even faster when the research output in life sciences is increasing in tandem.

From the above it is conjectured that:

*H5: Structural change indirectly, via research output, impacts on economic growth*

Figure 1 summarize all the hypotheses to be tested in the current study.

**FIGURE 1: THEORETICAL FRAMEWORK RELATING RESEARCH OUTPUT AND ECONOMIC GROWTH**




*Source*: Own elaboration

~~*Note:*~~ *Direct effect* - - - *Indirect effect*

## 3. METHODOLOGICAL CONSIDERATIONS

### 3.1. MAIN HYPOTHESES AND ECONOMETRIC SPECIFICATION

The main purpose of this study is to estimate the direct and indirect (via human capital and structural change) of research output, in aggregate and by distinct fields, on countries' economic growth.

Accordingly, the baseline econometric specification is:

$$y_{i,t} = \beta_1 + \beta_2 RO_{i,t,z} + \beta_3 HC_{i,t} + \beta_4 SC_{i,t} + \beta_5 X'_{i,t} + u_{i,t} \quad (1)$$

Where:

$y_{i,t}$ is the real GDP per capita for country *i* in the period *t,*

$RO_{i,t,z}$ represent the research output (number of articles and reviews published in sources indexed in Web of Science with GIPP scheme of the *z* area of research (All areas, Life science, Social Science, Base Clinical, Pre-Clinical and Health, Arts and Humanities, Engineering and Technology, Physical sciences and Social Sciences) for country *i* in the period *t;*

$HC_{i,t}$ presents the human capital (measured by the number of years of schooling of adult population (aged 25 or more) for country *i* in the period *t*;

$SC_{i,t}$ represents the structural change (comprises the weight of industry, in value added, in percentage of the GDP) for country *i* in the period *t;*

$X'_{i,t}$ represents a vector of control variables, which are likely to influence economic growth (e.g., public expenditures, research and development expenditure, researchers in R&D).

Enlarged model:

$$y_{i,t} = \beta_1 + \beta_2 RO_{i,t,z} + \beta_3 HC_{i,t} + \beta_4 SC_{i,t} + \beta_5 X_{i,t} + \beta_6 RO_z \times HC_{i,t} + + \beta_7 RO_z \times SC_{i,t} + v_{i,t} \quad (2)$$

Where $RO_z \times HC_{i,t}$ is the variable measuring the interaction between research output and human capital, and $RO_z \times SC_{i,t}$ is the variable measuring the interaction between research output and structural change.

### 3.2. SELECTED ECONOMETRIC ESTIMATION TECHNIQUE

In order to estimate the relation between research output and economic growth, the extant literature has advanced different methods (see Table A1, in Annex).

Despite of the summary table considers all the studies, including both single and multi-countries related studies, given the purpose of the current study, we focus on the methods used in studies that explore more than one country. In this latter set, some studies evaluate the countries individually using time series (e.g., Jin, 2009), whereas other use a panel data to evaluate the countries in aggregate (e.g., Solarin and Yen, 2016).

Focusing on panel data related methods, it is worth mention the bootstrap panel causality approach for multi country samples used by Ntuli et al. (2015) and Inglesi-Lotz et al. (2015). This approach takes in account the cross-section dependency across countries; ignoring such section-dependency could lead to bias and size distortion (Ntuli et al., 2015). The approach is based on seemingly unrelated regression (SUR) estimation of the set of equations and the Wald tests. It has an individual specific country bootstrap critical values which allows the variables in the system not to be stationary. Therefore, it is not necessary to apply any pre-testing for panel unit root and cointegration analyses.

In the line of Ntuli et al. (2015) and Inglesi-Lotz et al. (2015), we use random effect panel data model with bootstrapping.

### 3.3. PROXIES FOR THE RELEVANT VARIABLES AND MAIN DATA SOURCES

The database used in the current study covers the period from 1980 to 2016 for 65 countries. This dataset encompasses the proxies for the core variables – economic growth, research output, human capital and structural change - as well as for a limited number of 'control' variables (public consumption, research and development expenditure, and the number of researchers involved in R&D).

The key variables include Gross Domestic Product (GDP) per capita in constant 2010 US$. It is gathered from the World Development Indicators (World Bank, 2017). We follow most of the studies in the area which use as economic growth indicator the real GDP (see Jin 2009, 2010; Inglesi-Lotz et al., 2014; Ntuli et al., 2015; Inglesi-Lotz et al., 2015 Solarin and Yen, 2016; Kumar et al., 2016).

Again, in line with extant literature (e.g., Jin, 2009; Lee et al., 2011; Solarin and Yen, 2016), the research output is measured by the number of scientific articles published in sources indexed in Web of Science per 1000 inhabitants. We consider research output in global and by broad scientific areas, namely Arts & Humanities, Clinical, Pre-Clinical & Health, Engineering & Technology, Life Sciences, Physical Sciences, Social Sciences. We selected the data from the InCites dataset by research area using the GIPP scheme, for the period of 1980 to 2016 for each country in the analyze.[2] The broad areas are an aggregation of the Web of Science subject categories (see the mapping in Table A3, in Annex). It is important to note that the type of documents included is restricted to articles and reviews

Similarly to other studies (e.g., Easterly and Levine, 1997; Hall and Jones, 1999; Moral-Benito, 2012; Bodman and Le, 2013; Teixeira and Queirós, 2016), we consider the number of years of schooling of the adult population (individuals aged 25 or more) as the proxy for human capital. Data for this proxy comes from Barro and Lee 2010's data set, which provide data from 1950 to 2010, disaggregated for periods of five years. We fill in the intermediate values between the five years period by linear interpolation as Teixeira and Queirós (2016).

Structural change indicator is the weight of industry in total value added (O' Mahony and Timmer, 2009; Teixeira and Queirós, 2016). Such proxy is quite broad as more adequate data (e.g., weight of manufacturing or high-tech industries) for many countries is not available is gathered from the World Development Indicators database.

Finally, the control variable public expenditure is computed as the public consumption in percentage of the GDP, being gathered from the World Development Indicators database.

[2] The data are from InCites dataset that includes Web of Science content indexed through 2017-06-30, using the GIPP Discipline scheme. Incites website for further details: https://incites.thomsonreuters.com/

## 4. EMPIRICAL RESULTS

### 4.1. DESCRIPTIVE STATISTICS

Real GDP per capita has a mean of 19055 dollars, with a minimum of 164 dollars per capita for Ethiopia in 1992, and a maximum of almost 112 thousand dollars per capita in Luxembourg, in 2007 (see Table 2).

The overall research output reaches a minimum value of zero (no publications) and a maximum of almost 4 papers and reviews per thousand inhabitants. By area of research the maximum value is: 1.58 articles and reviews (per thousand inhabitant) in Life Science (Denmark, in 2016); 1.32 in Base Clinical, Pre-Clinical and Health (Denmark, in 2016); 1.26 in Physical sciences (Switzerland, in 2016); 0.96 in Engineering and Technology (Singapore, in 2016); 0.60 in Social sciences (Iceland, in 2016); and 0.16 in Arts and Humanities (United Kingdom, in 2013).

**TABLE 2: DESCRIPTIVE STATISTICS OF THE RELEVANT VARIABLES**

| Variable | Proxy | Obs. | Mean | Std. Dev. | Min | Max |
|---|---|---|---|---|---|---|
| Economic Growth | GDP per capita, PPP (constant 2011 international $) (thousands) | 2244 | 19.055 | 20.551 | 0.164 | 111.968 |
| All areas | Nº of the articles and reviews published in _____by the total number of the population (thousands) | 2320 | 0.507 | 0.676 | 0.000 | 3.913 |
| Life Science | | 2285 | 0.198 | 0.269 | 0.000 | 1.581 |
| Base Clinical, Pre-Clinical and Health | | 2266 | 0.150 | 0.215 | 0.000 | 1.325 |
| Arts and humanities | | 2108 | 0.014 | 0.022 | 0.000 | 0.161 |
| Engineering and Technology | | 2250 | 0.092 | 0.133 | 0.000 | 0.955 |
| Physical Sciences | | 2286 | 0.158 | 0.198 | 0.000 | 1.266 |
| Social Sciences | | 2234 | 0.048 | 0.088 | 0.000 | 0.602 |
| Human capital | Nº of the years of schooling of the population aged 25 or more | 1953 | 7.869 | 3.020 | 0.650 | 13.420 |
| Structural changes | Industry, value added (% of GDP) | 1899 | 30.066 | 7.944 | 4.486 | 56.592 |
| Public expenditure | Public consumption in % GDP | 2164 | 15.921 | 5.468 | 2.047 | 41.476 |

On average, for the whole sample of countries and period, human capital reaches 7.87 years of schooling of the population aged 25 or more, with a minimum of less than a year (0.65) for Benin in 1980, and a maximum around 13 years of schooling for Switzerland and the USA in 2010.

The average industry value added in percentage of the GDP is about 30%, with the minimum value of 4.5% for Uganda, in1980 and the maximum (56.6%) occurring for Romania in 1981.

#### 4.2. DIAGNOSIS TESTS

Before estimating the relevant econometric specifications, we run tests for assessing of the issues of heteroskedasticity and multicollinearity.

Breusch and Pagan test (1980), whose null hypothesis establishes that the error variance is not related to the explanatory variables (homoscedasticity), indicates that at a level of significance below 5%, we can reject the null hypothesis. Thus, the residuals are heteroskedastic (that is, their variance is not constant). In this case, the estimators are not efficient and consequently statistic inference is invalid. To overcome the problem of heteroskedasticity we use bootstrap standard error.

Regarding multicollinearity, we compute the Variance Inflation Factors (VIF), which provides an index that measures how much the variance (the square of the estimate's standard deviation) of an estimated regression coefficient is increased because of collinearity (Chatterjee and Hadi, 2012). According to Chatterjee and Hadi (2012) there is multicollinearity when VIFs are higher than 10. In the basic Models A (Table 3) VIFs are smaller than 5, which indicates no multicollinearity issues. As expected, due to the inclusion of interaction variables, multicollinearity issues are present in Models B (Table 4).

From the analysis of the correlations between the independent variables we found high correlations between the areas of research. For instance, ‘Life science’ is strongly correlated with ‘Base Clinical, Pre-Clinical and Health’, presenting a Pearson coefficient of 0.978. This very high correlations arise because one single article can be indexed in more than one area of research– in general, each journal is assigned to more than one area of research - which means that can be overlapping categories. In order to overcome this potential multicollinearity problem, we estimate one specification for each research area.

#### 4.3. ESTIMATION RESULTS

##### 4.3.1. BASIC MODEL - WITHOUT CONSIDERING INTERACTION EFFECTS

The baseline model specified previously (see eq. 1) intends to test the impact on the economic growth of the global research output (Model A) and the research output by areas of research (Model A1 - Life Sciences ; Model A2 - Base Clinical, Pre-Clinical and Health; Model A3- Arts and humanities; Model A4- Engineering and technology; Model A5- Physical sciences; Model A6 - Social sciences).

Estimations are presented in Table 3.

Considering as a whole, research output impacts significantly and positively on countries' economic growth. On average, keeping the other variables constant, if we change the overall research output by one percent, countries' economic growth changes by 0.61 percent. This result validates **H1a (“***The overall research output impacts positively on countries' economic growth*”) and goes in line with extant evidence (see Inglezi-Lotz *et al*. 2014; Inglezi-Lotz *et al*. 2015; Ntuli *et al*., 2015; Hatemi-J *et al*. 2016; Solarin and Yen, 2016).

Regardless the research area, each research output has a positive and significantly impact on economic growth, albeit with different estimated magnitude.

The results suggest a larger impact in the case of Arts and Humanities (Model A3). In this case, *ceteris paribus,* the change of one percent of the number of the articles and reviews published (per thousand inhabitants) in Arts and Humanities leads to an average change in real GDP per capita of 3.6 percent. In the remaining scientific areas, estimated economic growth's average impact is 1.24 percent in Engineering and Technology (Model A4), 1.20 percent in Physical Sciences (Model A5), 1.12 percent in Social Sciences (Model A6), 1.08 percent in Base Clinical, Pre-Clinical and Health (Model A2), and 0.99 percent in Life Science (Model A1).

Thus, the empirical results support **H1b** (“*The research output from distinct fields impacts positively but with distinct size effects on countries' economic growth*”).

As hypothesized, formal education of adult population and the weight of industry value added in total value added significantly and positively impacts on countries' economic growth. One percentage change in the years of schooling of the

population aged 25 or more leads, on average, all the remaining factors being held constant, an increase between 0.075 and 0.112 percent in real GDP per capita. Therefore, **H2 (“***Human capital directly impacts on economic growth*”) is validated.

In general, and excluding the estimations for the research areas Arts and Humanities (Model A3) and Social Sciences (Model A6), countries which experience an increase in the weight of the industry (in total value added) tend to grow faster. Thus, **H3** (“*Structural change towards an increased importance of industry impacts positively on economic growth*”) is validated for global research output, but it is only partially validated when research output is separated by scientific areas.

**TABLE 3: MARGINAL EFFECTS OF THE OVERALL AREAS OF THE RESEARCH ON THE ECONOMIC GROWTH**

| Variable | | Model A | Model A1 | Model A2 | Model A3 | Model A4 | Model A5 | Model A6 |
|---|---|---|---|---|---|---|---|---|
| **Research Output** (number of articles and reviews published in ____ by the total number of the population, per 1000) | **All areas of research** | 0.6092*** (0.0773) | | | | | | |
| | **Life Sciences** | | 0.9789*** (0.2057) | | | | | |
| | **Base Clinical, Pre-Clinical and Health** | | | 1.0858*** (0.2160) | | | | |
| | **Arts and humanities** | | | | 3.5595*** (0.8908) | | | |
| | **Engineering and Technology** | | | | | 1.242*** (0.2070) | | |
| | **Physical sciences** | | | | | | 1.2051*** (0.2260) | |
| | **Social sciences** | | | | | | | 1.1270*** (0.2953) |
| **Human capital** | Nº of years of schooling of the population aged 25 or more | 0.0746*** (0.0160) | 0.0842*** (0.0184) | 0.0910*** (0.0148) | 0.1121*** (0.0150) | 0.0844*** (0.0156) | 0.0764*** (0.0165) | 0.1034*** (0.0141) |
| **Structural change** | Industry, value added (% of GDP) | 0.0061** (0.0026) | 0.0052** (0.0025) | 0.0049** (0.0023) | 0.0035 (0.0025) | 0.0058* (0.0030) | 0.0061** (0.0027) | 0.0036 (0.0032) |
| **Public expenditures** | Public consumption in % GDP | 0.0023 (0.0056) | 0.0025 (0.0049) | 0.0024 (0.0063) | 0.0026 (0.0055) | 0.0038 (0.0051) | 0.0034 (0.0050) | 0.0024 (0.0055) |
| **Goodness of fit** | Number of observations (60 countries×36 periods) | 1430 | 1429 | 1428 | 1329 | 1406 | 1427 | 1412 |
| | Wald chi2 (p-value) | 359.24 (0.0000) | 183.50 (0.0000) | 124.09 (0.0000) | 163.67 (0.0000) | 223.61 (0.0000) | 182.65 (0.0000) | 147.15 (0.0000) |

Note: ***, **, and * indicate significance at the 0.01, 0.05 and 0.1 levels, respectively. All variables in numbers are in logarithms; Bootstrap critical values are obtained from 50 replications.

#### 4.3.2. ENLARGED MODEL - CONSIDERING THE INTERACTION EFFECTS

In the enlarged model (Table 4) it is considered the interaction of the overall and each area of research, with human capital and structural change. This allows to analyze the global, direct and indirect effects of research output on economic growth.

Regarding the global effect the impact of diverse areas of the research are positive on the economic growth. Thus, the hypothesis **H1a** ("*The overall research output impacts positively on countries' economic growth*") is confirmed. The results indicate that an increase of 1 percent in overall areas of research impact positively on economic growth by 0.88 percent, for significant level of 10 percent and keeping the other variables constants.

Looking at the magnitude, the area of the research with higher impact on economic growth is Arts and Humanities research output (Model B3), with 14.73 percent, for significant level of 10 percent and keeping the other variables constants. Followed by Social sciences research output (Model B6) by one percent, the economic growth changes by 5.71 percent, for significant level of 5 percent and keeping the other variables constants. For the level of significance of 10 percent, Life Science (Model B1) contributes, in global terms, by 2.11 percent to the economic growth, and the Base Clinical, Pre-Clinical and Health (Model B2) by 2.08 percent. It is interesting to note some areas of the research, as Engineering and Technology and Physical Sciences, are not statistically significant. Even with some areas of the research not statistically significant the results confirm **H1b** ("*The research output from distinct fields impacts positively but with distinct size effects on countries' economic growth*").

Regarding the human capital, the direct effect is positive and significant on economic growth at the level of the significance of 1 percent. The impact of an extra year of schooling is between 0.07 and 0.10 percent on economic growth. This empirical result confirms **H2** ("*Human capital directly impacts on economic growth*). The indirect effect of human capital via research output, i.e., the interaction of human capital with overall and each area of the research on economic growth is negative but not statistically significant. Therefore, there is no sufficient evidence to validate or invalidate **H4** ("*Human capital indirectly, via research output, impacts on economic growth*").

As the estimated coefficients of the (direct and indirect) effect of structural change on economic growth are not statistically significant, hypothesis **H3** ("*Structural change towards an increased importance of industry impacts on economic growth*") and **H5** ("*Change indirectly, via research output, impacts on economic growth*") cannot be validated/invalidated.

**TABLE 4: MARGINAL EFFECTS OF THE OVERALL AREAS OF THE RESEARCH ON THE ECONOMIC GROWTH WITH INTERACTION EFFECTS**

| | Variable | | Model B | Model B1 | Model B2 | Model B3 | Model B4 | Model B5 | Model B6 |
|---|---|---|---|---|---|---|---|---|---|
| Global Effects | Research Output (number of articles and reviews published in ____ by the total number of the population, per 1000) | **All areas** | 0.883* (0.4863) | | | | | | |
| | | **Life Science** | | 2.1090** (0.6942) | | | | | |
| | | **Base Clinical, Pre-Clinical and Health** | | | 2.0814** (1.0487) | | | | |
| | | **Arts and Humanities** | | | | 14.7290* (8.3410) | | | |
| | | **Engineering and Technology** | | | | | 0.4884 (1.1813) | | |
| | | **Physical Sciences** | | | | | | 1.2270 (0.7943) | |
| | | **Social Sciences** | | | | | | | 5.7100** (2.5369) |
| | **Human capital** | N° of years of schooling of the population aged 25 or more | 0.0742*** (0 .0182) | 0.0837*** (0.0178) | 0.09207*** (0.0155) | 0.1138*** (0.0166) | 0.0844*** (0.0334) | 0.0765*** (0.0176) | 0.1024*** (0.0149) |
| | **Structural changes** | Industry, value added (% of GDP) | 0.0043 (0.0029) | 0.0040 (0.0028) | 0.0035 (0.0027) | 0.0025 (0.0033) | 0.0046* (0.0027) | 0.0043 (0.0027) | 0.0031 (0.0030) |
| Direct Effects | Research Output (number of articles and reviews published in ____ by the total number of the population, per 1000) | **All areas** | 0.5637*** (0.1278) | | | | | | |
| | | **Life Science** | | 0.9065*** (0.2274) | | | | | |
| | | **Base Clinical, Pre-Clinical and Health** | | | 0.8713** (0.3209) | | | | |
| | | **Arts and Humanities** | | | | 1.5034 (0.9606) | | | |
| | | **Engineering and Technology** | | | | | 1.169*** (0.4544) | | |
| | | **Physical Sciences** | | | | | | 1.1572*** (0.2081) | |
| | | **Social Sciences** | | | | | | | 0.5925* (0.3218) |
| | **Human capital** | N° of years of schooling of the population aged 25 or more | 0.0608** (0.0255) | 0.0709** (0 .0317) | 0.0882** (0.0304) | 0.1255*** (0.0271) | 0.0592** (0.0272) | 0.0574** (0.0722) | 0.0897** (0.0761) |
| | **Structural change** | Industry, value added (% of GDP) | 0.0025 (0.0078) | -0.0001 (0.0070) | -0.0055 (0.0187) | -0.0026 (0.0041) | 0.0033 (0.0061) | 0.0043 (0.0057) | -0.0020 (0.0046) |
| Indirect effect | **Interaction** | Industry × research output (each area of research) | 0.0929 (0.1889) | 0.1402 (0.1638) | 0.5674 (0.5482) | 0.1960 (0.1240) | 0.0914 (0.1565) | 0.3978 (0.3821) | 0.1610 (0.1181) |
| | | Human capital × research output (each area of research) | -0.0430 (0.1587) | -0.0798 (0.144) | -0.2807 (0.5319) | -0.1398 (0.1240) | -0.03987 (0.1343) | -0.0043 (0.122) | -0.0881 (0.1116) |
| [illegible] | **Public expenditures** | Public consumption in % GDP | 0.0025 (0.0059) | 0.0008 (0.0051) | -0.0013 (0.0051) | 0.0011 (0.0050) | 0.00346 (0.0049) | 0.0031 (0.0040) | 0.0001 (0.0048) |
| **Goodness of fit** | | Number of observations (60 countries×36 periods) | 1430 | 1429 | 1428 | 1312 | 1405 | 1427 | 1410 |
| | | Wald chi2 (p-value) | 381.83 (0.0000) | 450.08 (0.000) | 515.15 (0.0000) | 548.79 (0.0000) | 483.5 (0.0000) | 281.69 (0.0000) | 817.59 (0.0000) |

*Note:* all variables in numbers are in logarithms
Note: ***, **, and * indicate significance at the 0.01, 0.05 and 0.1 levels, respectively. Bootstrap critical values are obtained from 50 replications.

## 5. CONCLUSION

Based on the panel data of 65 countries over 36 years (1980 to 2016), the present study estimated the impact of research output on economic growth at the global and by areas of science, highlighting the mediating roles, via research output, of human capital and structural on economic growth.

The study contributes to the scientific literature in different ways. First, our results demonstrate that the research output impacts positively on the economic growth both at the global levels and by area of research. This confirms the findings of the scientific literature which found evidence that research output positively affects economic growth.

Second, the results indicate that the magnitude of the effect of research output on economic growth depends on the research area. In the baseline model (without interactions effects), the results suggest that 'Arts and Humanities' has the biggest impact on the economic growth, at a significant distance from the other areas of research. It is followed by 'Engineering and Technology' and 'Physical Science'. The extensive impact of Arts and Humanities is likely to be related to the fact that for studying Arts and Humanities there is no need of an extensive investment in equipment or infrastructures. Moreover, this area of research contributes in a more general and encompassing way to economic growth, being useful for a wider set of industries and/or activities. When it is considered interaction effects, we still found positive and significant effect of research output on economic growth, albeit in the case of Engineering and Technology and Physical Science the global effects ceased to be statistically significant. Nevertheless, the direct effect of 'Engineering and Technology' and 'Physical Science' research output on growth is positive.

Third, the empirical results suggest a positive and significant direct effect of the human capital on economic growth. This finding confirms the scientific literature that defend a positive impact of human capital on economic growth.

Fourth, the direct impact of Structural change, measured by the industry, value added percentage of GDP, is not significant to explain the economic growth.

Fifth, when it is considered the interaction of human capital and structural change, via research output, on economic growth are not statistically significant.

Concerning the policy implications, the impact of research output on the economic growth is thus very important for policy purposes. Understanding which research areas of science matter the most for increasing economic performance, the government can prioritize the areas of research.

Future research on this topic could include other variables to analyze the interaction. Also, would be interesting to observe evolution of the impact of each area over the time on the economic growth.

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**Table A1: Summary of the empirical studies on the relation between research output and economic growth**

| | Study | | Countries | Data | Methodology | Economic growth variable | Research output variable | Results |
|---|---|---|---|---|---|---|---|---|
| Aggregate research output | Hatemi-J *et al*. (2016) | | G7 countries | 1981-2012 | Asymmetric panel causality test of Hatemi-J (2011); VAR-SUR(p) model | Natural logarithm of the real GDP | Natural logarithm of the number of research papers published by the % of the total numbers of the papers published in the world | UK: RO => EG; Other countries: 0 |
| | Kumar *et al*. (2016) | | China and US | 1981–2012 | ARDL- Autoregressive distributed lag method and Toda and Yamamoto | Real GDP | Research of scientific and technical papers as a percent of World | China RO <=> EG; US, RO <= EG |
| | Solarin and Yen (2016) | | 169 countries | 1996-2013 | GMM estimate (in neoclassical framework) | Real per capita GDP growth | Research publication per capita | In general: RO => EG |
| | Inglesi-Lotz *et al*. (2015) | | BRICS | 1981-2011 | Bootstrap panel- Granger causality approach | Total real GDP in constant 2005 US dollars | Research papers published in terms of percentage share to the world | India: RO <=> EG: Others: 0 |
| | Ntuli *et al*. (2015) | | 34 OCDE countries | 1981-2011 | | Total real GDP in constant 2005 US dollars | Research articles published in terms of the total number of articles published | RO => EG for US, Finland, Hungary, and Mexico; RO <= EG: Canada, France, Italy, New Zealand, the UK, Austria, Israel, and Poland; the rest of the countries:0 |
| | Inglesi-Lotz *et al*. (2014) | | US | 1981-2011 | Bootstrap rolling-window causality tests; VSTAR regime-switching model | Real GDP at constant 2005 US dollars | share of the country's number of publications to the world | RO => EG, without opposite causality |
| | Lee *et al*. (2011) | | 25 countries | 1981-2007 | Granger causality | Nominal GDP data in US dollars | Research papers published | Mutual causality between research and economic growth in Asia, the causality is much less clear in Western countries |
| Research output by area | Biotechnology | Yasgul and Guris (2016) | Turkey | 1981–2013 | Bootstrap Granger causality test | Real GDP with fixed prices of 2005 | ratio of biotechnology publications to total publications | Turkey: RO => EG |
| | Science and Engineering, Science and Nature, Business Education, Economic | Jin and Jin (2013) | 46 countries | 1975-2003 | Granger causality | Average annual growth rate of per capita real GDP | Publications per million people | In general: RO => EG |
| | Biology and Biochemistry, Chemistry, Material Sciences, Physics, Psychiatry and Psychology | Inglesi-Lotz and Pouris (2013) | South Africa | 1980-2008 | ARDL- Autoregressive distributed lag method | GDP in constant 2005 prices | Research output as a share of South African publications in relation to the rest of the world | South Africa: RO => EG |
| | Economics | Jin (2010) | Japan | 1970-2004 | Granger causality | real per capita GDP in 2000 prices | Research publication per million people | Japan RO <= EG |
| | Economics | Jin (2009) | East Asian economies | 1969–2004 | | Real GDP in 2000 prices | Total publication | Hong Kong: RO <=> EG; South Korea and Taiwan RO => EG; Japan RO <= EG; Singapore: 0 |
| | Chemical engineering | Hart and Sommerfeld (1998) | 5 countries (United States, Canada, Great Britain, India and Australia) | 1970-1996 | Linear correlations | GDP | 5-years average Annual number of academic chemical engineering publications for the USA | United States, Canada, Great Britain, India and Australia: RO => EG |

*Legend*: => one direction causality; <=> mutual direction causality; 0 no significant causality

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# 6 Sustainable Development

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## 6.1 F1. Intra and extra-EU trade in recyclable materials and circular economy: a critical appraisal of the European Commission's monitoring framework - Leandro Javier Llorente González, Xavier Vence Deza



*COMERCIO DE MATERIALES RECICLABLES INTRA Y EXTRA-UE Y ECONOMÍA CIRCULAR: UNA VALORACIÓN CRÍTICA DEL MARCO DE SEGUIMIENTO DE LA COMISIÓN EUROPEA*

*COMÉRCIO DE MATERIAIS RECICLÁVEIS INTRA E EXTRA-UE E ECONOMÍA CIRCULAR: UMA AVALIAÇÃO CRÍTICA DO QUADRO DE CONTROLO DA COMISSÃO EUROPEIA*

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*ABSTRACT*

In recent years, the shift to a circular economy (CE) has become an increasingly important component of the European Union's development strategy. The European Commission presented in 2018 a monitoring framework to assess the progress made in this transition, focusing on the priority objectives of the European strategy for the CE. This article aims to examine the selection and interpretation of metrics proposed by the Commission, with an emphasis on trade in recyclable materials within the EU and between the EU and the rest of the world. It is argued that the indicators chosen are largely concerned with material self-sufficiency and recycling, neglecting other dimensions of the concept more closely related to systemic change. In addition, the analysis of available information overlooks two central issues from the CE perspective, such as the continued leakage of recyclable waste to the rest of the world, and the uneven distribution of secondary raw material flows between EU Member States in terms of value and environmental impact.

*Keywords: circular economy, monitoring framework, trade in recyclable materials, systemic change, secondary raw materials.*

*RESUMEN*

En los últimos años, el cambio hacia una economía circular (EC) se ha convertido en un componente cada vez más importante de la estrategia de desarrollo de la Unión Europea. La Comisión Europea presentó en 2018 un marco de seguimiento para evaluar los progresos realizados en esta transición, centrado en los objetivos prioritarios de la estrategia europea para la EC. Este artículo tiene como objetivo examinar la selección e interpretación de las métricas propuestas por la Comisión, haciendo hincapié en el comercio de materiales reciclables al interior de la UE y entre la UE y el resto del mundo. Se argumenta que los indicadores elegidos conciernen mayormente a la autosuficiencia de materiales y al reciclaje, descuidando otras dimensiones del concepto más estrechamente relacionadas con el cambio sistémico. Además, en el análisis de la información disponible se pasan por alto dos cuestiones centrales desde la perspectiva de la EC, como son la sostenida fuga de desechos reciclables hacia el resto del mundo, y la dispar distribución de los flujos de materias primas secundarias entre los Estados miembros de la UE en términos de valor e impacto medioambiental.

*Palabras clave: economía circular, marco de seguimiento, comercio de materiales reciclables, cambio sistémico, materias primas secundarias.*

*RESUMO*

Nos últimos anos, a mudança para uma economia circular (EC) tornou-se uma componente cada vez mais importante da estratégia de desenvolvimento da União Europeia. A Comissão Europeia apresentou em 2018 um quadro de controlo para avaliar os progressos realizados nesta transição, centrando-se nos objetivos prioritários da estratégia europeia para a EC. Este artigo visa examinar a selecção e interpretação dos parâmetros propostos pela Comissão, com ênfase no comércio de materiais recicláveis na UE e entre a UE e o resto do mundo. Argumenta-se que os indicadores escolhidos dizem principalmente respeito à auto-suficiência dos materiais e à reciclagem, negligenciando outras dimensões do conceito mais estreitamente relacionadas com a mudança sistémica. Além disso, a análise da informação disponível ignora duas questões centrais do ponto de vista da EC, como a fuga contínua de resíduos recicláveis para o resto do mundo e a distribuição desigual dos fluxos de matérias-primas secundárias entre os Estados-Membros da UE em termos de valor e impacto ambiental.

*Palavras-chave: economia circular, quadro de controlo, comércio de materiais recicláveis, mudança sistémica, matérias-primas secundárias.*

*Clasificación JEL: Q01, Q51, Q55, Q56.*

Scientific area according to the congress list: 4 - 6

Is it candidate to the José Luís Sampedro Prize/Award? Yes [X] No [ ]

## 1. Introduction

In December 2015, the European Commission issued an action plan for the circular economy (CE), as part of the new circular economy package[1]. The plan consists of a list of actions through which the Commission commits to support the transition to CE, aiming to set "the right regulatory framework" for its development (EC, 2015).
According to the plan, it is expected that Member States of the EU improve and converge towards the best practices and results regarding CE. To measure the degree of progress in these objectives, detect success factors and evaluate whether enough actions were undertaken, the European Commission prepared in 2018 a monitoring framework for the CE (EC, 2018a). The selected indicators focus mainly on measuring the progress towards reduction of waste generation, increase of recycling and use of secondary raw materials.
This article aims to discuss the selection and interpretation of the metrics proposed by the European Commission, with an emphasis on trade in recyclable materials within the EU and between the EU and the rest of the world. It is argued that the chosen indicators are mostly concerned with the Commission's strategic priorities for material self-sufficiency and recycling, neglecting the more transformative systemic dimensions of the concept. Moreover, some issues that are relevant from a CE perspective, such as the continued leakage of recyclable waste to the rest of the world, and the disparate distribution of recyclable material flows among EU Member States in terms of value and environmental impact, are overlooked in the interpretation of the available information.
The next section presents the CE monitoring framework together with three relevant country-level proposals of metrics for assessing CE. The third section addresses the first results of the monitoring framework and offers an alternative analysis of the available data regarding trade of secondary raw materials. The fourth section summarizes the main conclusions.

## 2. Measuring circular economy

In January 2018, the European Commission (EC) released a monitoring framework with the objective of tracking the degree of compliance of the circular economy action plan. The framework is based on two tables of indicators previously elaborated to assess the progress towards its priority goals on Environment (Resource Efficiency

[1] It replaced the initial circular economy package, considered narrower in scope, presented in July 2014. It is available at:
http://www.europarl.europa.eu/RegData/etudes/BRIE/2014/545704/EPRS_BRI(2014)545704_REV1_EN.pdf
The new circular economy package is available at:
http://www.europarl.europa.eu/EPRS/EPRS-Briefing-573936-Circular-economy-package-FINAL.pdf

Scoreboard[2] and Raw Materials Scoreboard[3]). According to the communication from the EC, the criterion that guided the preparation of the framework was to avoid higher administrative costs, together with "relevance, acceptance, credibility, ease of use and robustness" of data (EC, 2018a, p.5). The monitoring framework consists of a set of ten indicators grouped into four stages, related to the priorities pointed out by the Commission in the CE action plan (Table 1).

TABLE 1. INDICATORS INCLUDED IN THE MONITORING FRAMEWORK FOR CE

| *No* | *Name* | *Relevance* |
|---|---|---|
| Production and consumption | | |
| 1 | EU self-sufficiency for raw materials | The circular economy should help to address the supply risks for raw materials, in particular critical raw materials. |
| 2 | Green public procurement* | Public procurement accounts for a large share of consumption and can drive the circular economy. |
| 3a-c | Waste generation | In a circular economy waste generation is minimised. |
| 4 | Food waste* | Discarding food has negative environmental, climate and economic impacts. |
| Waste management | | |
| 5a-b | Overall recycling rates | Increasing recycling is part of the transition to a circular economy. |
| 6a-f | Recycling rates for specific waste streams | This reflects the progress in recycling key waste streams. |
| Secondary raw materials | | |
| 7a-b | Contribution of recycled materials to raw materials demand | In a circular economy, secondary raw materials are commonly used to make new products. |
| 8 | Trade in recyclable raw materials | Trade in recyclables reflects the importance of the internal market and global participation in the circular economy. |
| Competitiveness and innovation | | |
| 9a-c | Private investments, jobs and gross value added | This reflects the contribution of the circular economy to the creation of jobs and growth. |
| 10 | Patents | Innovative technologies related to the circular economy boost the EU's global competitiveness. |

* Indicators under development.
Source: European Commission (2018a).

Prior to the launch of the EU Monitoring Framework, some proposals of assessment schemes for the CE had been made at the national level. This is the case of the framework initiatives developed in France (Magnier, 2017), Spain (Morato et al., 2017) and Netherlands (Potting et al., 2018). The first one consists of ten indicators, of which three are currently part of the EU monitoring framework (food waste, use of recycled raw materials and employment in the circular economy). It also contains three metrics that can be obtained from the Eurostat database but are not included in the CE

[2] Available at: http://ec.europa.eu/environment/resource_efficiency/targets_indicators/scoreboard/index_en.htm
[3] Available at: https://publications.europa.eu/en/publication-detail/-/publication/1ee65e21-9ac4-11e6-868c-01aa75ed71a1

statistics (domestic material consumption per capita, resource productivity and waste sent to landfills). The main difference between the French proposal and the EU framework is that the former involves matters related to the initial phases of the product cycle (number of eco-label holders and industrial and territorial ecology projects) and to sustainable consumption (car-sharing and household spending in product repair and maintenance), thus suggesting a somewhat broader view on the CE.

The proposal developed in Spain is presented as an approach to an integrated assessment system based on the material flow analysis methodology. Although being structured around one main indicator, resource productivity, it consists of 14 "framework and context" metrics concerning material inputs, eco-design, waste from production and consumption, recycling, energy, climate, water and soil, together with 5 thematic indicators (food, construction, eco-innovation, taxation and tourism). Beyond the main focus on materials productivity and efficiency, the proposed indicators show a greater concern to cover the different phases of the production cycle. A more systemic perspective is also suggested by the selection of metrics such as energy efficiency, use of renewable energy and water sources, carbon intensity, waste taxes and tax incentives for sub-products.

The third monitoring framework proposal aims to measure the degree of progress in the Netherlands' transition to the CE. This means that, in addition to assessing the current state of CE in the country, it also seeks to evaluate the government policy actions undertaken and the transition dynamics that yielded the observed effects. The transition dynamic is mainly based on the innovation process entailed by the shift to the CE, which involves taking into consideration both the formative and the growth phases (Potting et al., 2018). To evaluate the formative phase, the Dutch framework proposes to measure the degree of support that organisations receive from the national innovation system in terms of capacity, motivation and permission. The indicators are also divided according to their link with inputs, throughputs, outputs and core achievements. For illustrative purposes, Table 2 presents an example of each type of indicator (for the complete set of suggested metrics see Potting et al., 2018).

TABLE 2. SUGGESTED INDICATORS FOR TRANSITION DYNAMICS MONITORING FOR CIRCULARITY INITIATIVES.

| | **Capacity (able to)** | **Permission (allowed to)** | **Motivation (want to)** |
|---|---|---|---|
| **Means (input)** | Number of CE researchers | Number of CE policy advisers | Number of people working on developing CE visions and transition agendas |
| **Activities (troughput)** | Number of CE innovation projects | Policy process for new CE laws and regulations | Number of awareness campaigns |
| **Achievements (output)** | Number of new CE products | Number of legal and regulatory barriers to the CE removed | Consumer perception of CE |
| **Core achievements** | Circularity strategies | | |

Source: Potting et al. (2018).

While the three proposals contain some indicators that are not yet developed or available at the EU level, these are approaches with a broad and systemic vision of CE from which the European framework could benefit greatly. In this regard, the following are some metrics that have been left out of the EU monitoring framework and whose incorporation is proposed for further discussion.

## 2.1 Earth, water, air… and energy!

Considering the emphasis of CE on preserving the value of all resources, it is striking that the monitoring framework only focuses on materials while neglecting to measure the effects of economic activity on land, water and air, together with such a fundamental input as energy. Even more so when in most cases indicators are available, some of which are part of other sets of metrics in Eurostat's database. This is the case of the indicators included in the Spanish proposal regarding energy productivity, share of renewable energies, carbon intensity and built-up land. Greenhouse gas emissions per capita, pollutant emissions from transport and productivity of artificial land are also available at the Eurostat's database, while water abstraction, productivity and exploitation index are accessible as well, yet not for every EU Member State.

It could be argued that the mentioned indicators do not need to be included in the monitoring framework for CE because they are already part of other specific sets of metrics, such as those related to the Europe 2020 targets or the Sustainable Development goals. However, many other multidimensional indicators can be found in several different thematic axes when their scope and definition require so. The incorporation of the existing indicators about land, water, emissions and energy in the monitoring framework could contribute to disseminate a broader notion of the CE without incurring into extra costs.

Furthermore, a comprehensive assessment of the level of circularity of the European economy cannot fail to take account of its effects on other territories. In this sense, indicators of water footprint, land and emissions should be included in the statistics as well.

## 2.2 An innovation system for system innovation

As highlighted in the Dutch proposal, the socio-institutional and productive change involved in the transition to the circular economy requires the support of an appropriate innovation system. In terms of metrics, this translates into the need to measure not only the environmental and social effects but also the actions and resources set in motion to promote circular innovations (Potting et al., 2018). In this sense, efforts should be done to develop indicators such as the number and share of CE researchers, investments and projects (inputs and throughputs), as well as new CE products, business models, start-ups and publications (outputs). The EU monitoring framework currently includes a metric about the number of patents related to recycling and secondary raw materials, thus recognizing the relevance of innovation activities for the transition to CE. Yet, the scope of the indicator is again limited to waste treatment and materials, while focusing only on the outputs of the innovation process.

Institutional drivers, such as the regulatory framework and tax structure are also critical to generate the right incentives and conditions for innovation in CE. Data about current legal enablers and barriers for the transition should be taken into consideration into the assessment, along with taxation to resource extraction and waste generation, and subsidies to R+D+I in CE, sub-products, reuse and circular activities in general.

The resource efficiency indicators of the Europe 2020 strategy include data on environmental and energy taxes, which could also be included in the CE monitoring framework. In addition, a combined analysis of the available variables can provide useful evidence for decision making.

### 2.3 Circular economy is about making things last longer

Product lifespan is a key dimension for a system approach to CE, as it depends and impacts on every phase of the value chain, and has a direct effect on both the rate of extraction of natural resources and the level of waste generation. Still, metrics concerning this matter are the least frequent, as pointed out by Elia et al. (2017) and Parchomenko et al. (2019). It is therefore vital for a comprehensive monitoring framework to develop indicators to track the average durability of products, together with its main determinants, such as the extent of eco-design, repair, reuse and collaborative consumption activities.

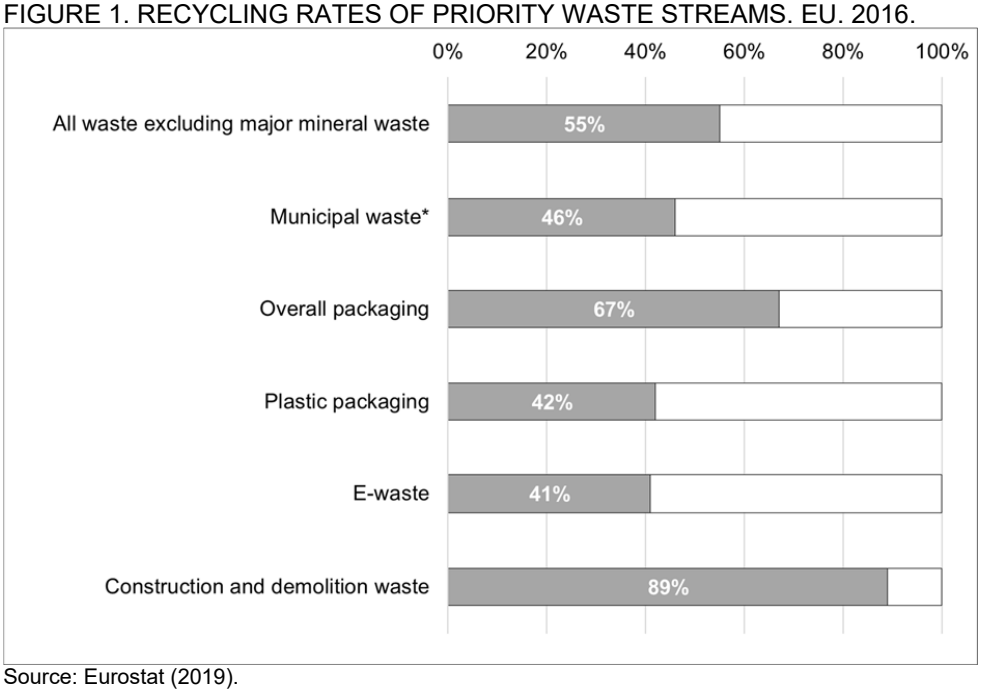
## 3. Progress towards circular economy

The first results of the monitoring framework are expected to serve as the baseline against which to measure progress towards the CE (EC, 2018a). Regardless of the mentioned limitations in relation to the availability and selection of indicators, the interpretation of the data requires an approach according to the specific objectives of CE. In this section, the main results highlighted by the commission are presented, followed by an alternative complementary analysis that attempts to make a further inquiry about what data show in terms of value retention of recyclable materials in the different Member States.

### 3.1 First results of the monitoring framework

In the communication introducing the monitoring framework the Commission points out that, in recent years, the largest developments towards CE have been made in waste management, i.e. recycling activities (EC, 2018a). In the same sense, a recent press release highlights that in 2016 record recycling rates were achieved, with the highest ratios observed in construction materials and packaging (Figure 1). However, the use of secondary (recycled) raw materials is reported to be low, as they only account for the 12% of the overall materials demand. The Commission also shows great concern about the high degree of dependency of the EU on imports of key raw materials.

FIGURE 1. RECYCLING RATES OF PRIORITY WASTE STREAMS. EU. 2016.




Source: Eurostat (2019).

A fall in the generation of both municipal waste and total waste between 2006 and 2016 (-8% and -11%, respectively) is presented as a sign of general progress towards CE. Nevertheless, the communication also mentions great differences between Member States and a certain correlation with per capita GDP.

Regarding extra-EU trade in secondary raw materials, data for the period 2004-2016 show a large surplus, both in value and volume, while intra-EU trade experienced a remarkable increase in the same time frame. These results are considered to be positive, as the description of the indicator made in the Commission's Staff Working Document (SWD) suggests that higher levels of trade of secondary raw materials could signal the presence of a dynamic internal market and an optimal use of EU's recycling capacities (EC, 2018b).

Finally, the contribution of the CE to overall competitiveness and innovation is measured based on the number of jobs, added value, private investments and patents developed in companies of economic sectors that are considered especially relevant to the CE. These involve recycling, repairing and reuse activities (EC, 2018b). In this sense, it is outlined that the level of circularity of European economies is still very low.

### 3.2 Further analysis of the first results

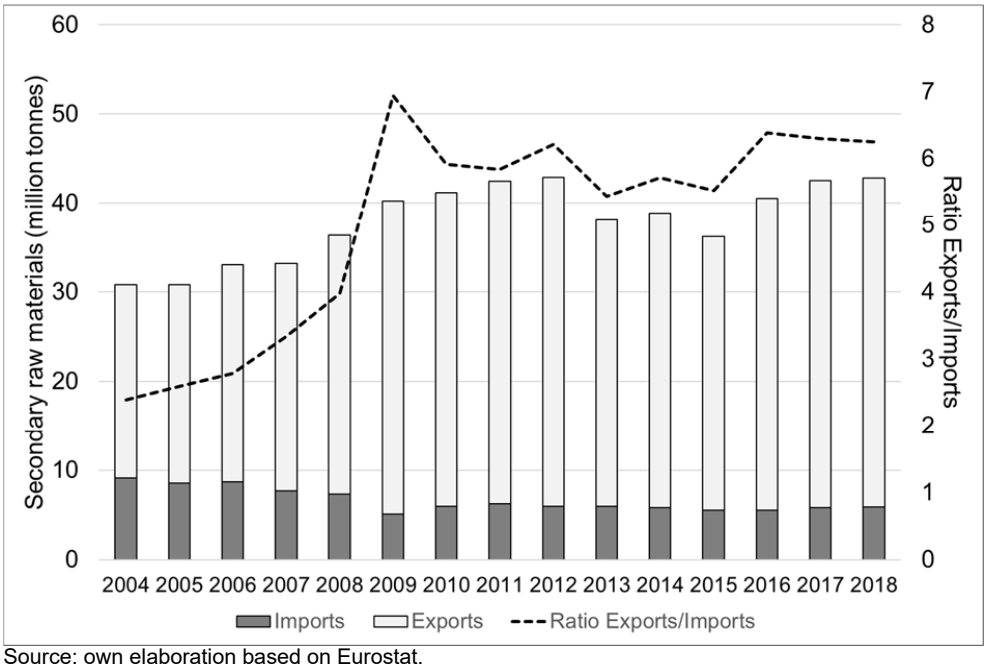
Beyond the results highlighted in the Commission's communication, the databases displayed at Eurostat's website allows to conduct complementary analyses concerning the situation of CE in the EU and its Member States. In this sense, an attempt to review the available data from the theoretical approach of CE, thus focusing on resource and value preservation rather than on economic growth and value exchange, led to a different interpretation of some of the results.

3.2.1 Extra-EU trade in recyclable raw materials: efficient markets or materials leakage?

It has been pointed out previously that trade in secondary raw materials is regarded by the Commission as an indicator of market dynamism and the level of efficiency in the use of EU's recycling capabilities (EC, 2018b). It was also mentioned that "secondary raw materials" is another way to refer to a variety of commodities that, though capable of being recycled, are still waste unless they receive the proper recovery treatment[4]. This means as well that the final destination of these materials is unknown once they cross national borders, a fact that could mislead the interpretation of data if it is left out of the analysis.

Data show a wide positive gap between EU's exports and imports of recyclable waste in every year of the available series (2004-2018). In terms of the balance of trade, this implies a remarkable and sustained commercial surplus that, in 2018 alone, reached 4.8 thousand million euro. However, from a CE approach, the same data could be interpreted as proof of a continuous leakage of potential secondary raw materials, which the EU lacks the capabilities to process and reuse within its boundaries. Waste trade data in terms of weight presents evidence in this direction. In the year 2018, the amount of recyclable waste leaving the EU measured in tonnes exceeded in more than five times the mass of those that were imported. This gap has remained relatively constant since 2010, when it peaked as a result of a 42% decrease in imports alongside with a 45% increase of exports between 2006 and 2009 (Figure 2).

FIGURE 2. EU TRADE IN SECONDARY RAW MATERIALS WITH NON-EU COUNTRIES.




Source: own elaboration based on Eurostat.

[4] This involves waste of metal, paper, rubber and plastic. For more details, see Eurostat (2018).

The composition of EU's trade flows also presents several differences in terms of market value per tonne of waste, as the average price of imports has been more than three times that of exports since 2013. This can be partly explained by differences in the type of the materials traded. In 2018, the share of recyclable precious metals waste (the most valuable type of secondary raw material) in EU's imports was twenty times greater than its participation in exports. Besides, market value of imported recyclable waste of plastics, iron, steel, copper, aluminium and nickel was in all cases between a third and 99% higher than that of the exported materials (Table 3).

TABLE 3. EU TRADE IN SECONDARY RAW MATERIALS WITH NON-EU COUNTRIES BY MATERIAL TYPE. 2018.

| Type | Share (tonnes) | | | Avg. Value (euro/tonne) | | |
|---|---|---|---|---|---|---|
| | Exports (X) | Imports (M) | Ratio M/X | Exports (X) | Imports (M) | Ratio M/X |
| Total | 100% | 100% | 1.0 | 379 | 1,555 | 4.1 |
| Plastics | 8.0% | 7.4% | 0.9 | 183 | 364 | 2.0 |
| Paper and cardboard | 28.5% | 26.7% | 0.9 | 138 | 160 | 1.2 |
| Iron and steel | 58.5% | 47.9% | 0.8 | 296 | 434 | 1.5 |
| Precious metals | 0.1% | 2.5% | 23.8 | 47,533 | 33,193 | 0.7 |
| Copper, aluminium and nickel | 4.8% | 15.6% | 3.2 | 2,090 | 2,776 | 1.3 |

Source: own elaboration based on Eurostat.

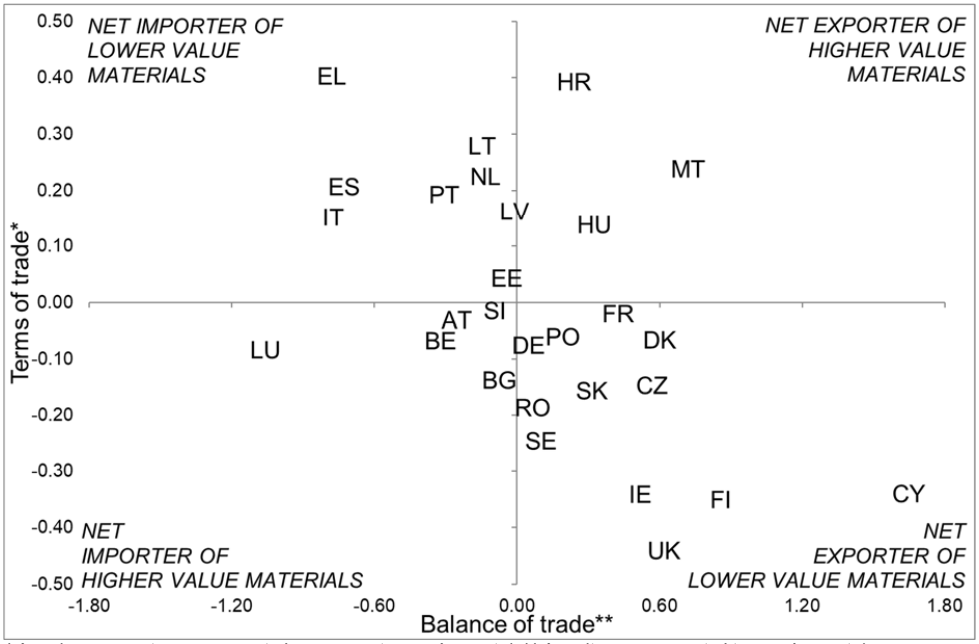
In conclusion, currently available data show a potential lack of capabilities on the part of the EU to successfully close the cycle of many material flows. Moreover, EU's countries may also be relocating part of the negative environmental impacts of their low-value waste to other parts of the world trough international trade. Further analysis with a higher level of detail regarding the different material types should be conducted to contribute to the research on this matter.

3.2.2 Intra-EU trade in recyclable raw materials: who gets the most value?

In addition to the overall leakage of secondary raw materials through international trade, available data also show large disparities between Member States regarding their capacity to retain valuable materials. From a CE perspective, it could be assumed that a negative trade balance and "unfavourable" terms of trade for secondary raw materials should be regarded as a positive outcome, as they would reflect a greater inflow (or smaller outflow) of the most valuable materials.
According to this logic, it is possible to divide EU Member States into four groups considering the direction and average value of the flows of recyclable materials within the EU, as it is shown in Figure 3. The quadrants are obtained combining the logarithmic representation of two proxy variables, "trade balance" and "terms of trade". The first variable was calculated by dividing the mass of exports over imports, in tonnes, while the terms of trade were estimated as the ratio between the average value of exports and imports, in euros per tonne of material. Average annual data for the period 2010-2018 were used.
From a CE point of view, the most favourable situation would correspond to the lower left quadrant, in which Luxembourg, Belgium, Austria, Bulgaria and Slovenia are located. The opposite could be said of the upper right quadrant, comprising Malta, Croatia and Hungary, all of which are net exporters of recyclable materials with a higher average value than that of those they import. Most countries are located in the two remaining quadrants, in an intermediate situation that, however, has also relevant

implications from the point of view of CE. On the one hand, there is a large group of net exporters of recyclables that, at the same time, attract the most valuable materials. This is the case of United Kingdom, Cyprus, Finland and Ireland, among others. On the other end, a number of Member States, such as Greece, Spain, Italy and Portugal, are net importers of the least valuable materials from the rest of the EU.
These results seem to suggest an uneven distribution of the metabolism system of recyclable materials across the EU. In addition, the significant differences in value of the materials processed in each Member State appear to reproduce, in some cases, the existing disparities in terms of development and complexity of their productive structure.

FIGURE 3. BALANCE AND TERMS OF TRADE IN SECONDARY RAW MATERIALS. INTRA EU-28. AVERAGE VALUES 2010-2018.




** Log(euro per tonne exports/ euro per tonne imports) ** Log(tonne exports/ tonne imports).*
Source: own elaboration based on Eurostat.

Of course, this analysis is not without limitations, related either to the choice and construction of the proxy variables, or to the debatable assumptions on which it is based. Moreover, a detailed analysis of the type of materials that make up the trade flows and of the treatment they receive at destination would be required in order to establish their effective impact in terms of circularity. Trends over time would also be of great relevance in this sense. However, the main purpose of this exercise is to illustrate that available data can offer a more complex and relevant panorama from a CE perspective if, besides focusing on the volume of trade in secondary raw materials, attention is paid also to the level of value retention and attraction of the EU as a whole, and of each of its Member States.

## 4. CONCLUSIONS

The monitoring framework developed by the European Commission is undoubtedly a valuable contribution to the task of measuring the degree of progress towards CE. However, there is little point in the effort to develop and exploit novel sources of value preservation data, if the results are to be judged from the traditional perspective of economic growth and value creation.

In this sense, there are significant differences in the results obtained from the monitoring framework if the analysis focus on value conservation rather than value added. This especially applies to the analysis of international flows of secondary materials. The increase in the volume of trade in recyclable waste together with the large trade surplus reflected in data for the EU may not imply good news from the point of view of value preservation and global sustainability. On the contrary, those results could be pointing to a deficit of capabilities to retain the value of certain recyclable materials within EU economies. Besides, as the final destination of the secondary materials exported by the EU is not known, they may as well end their life cycle as waste in countries with a less strict environmental legislation. In any case, it should be kept in mind that the environmental impact of the European economy does not end at the EU border.

Moreover, data about trade flows of secondary materials within the EU show that the "dynamic internal market and optimal use of EU recycling capacities" (EC, 2018b, p.37) may actually be determining the emergence of winners and losers in terms of value retention and potential environmental impacts.

Regarding the scope of the monitoring framework, it has been argued that several topics that reflect the systemic and global character of the CE are currently absent. This is the case of issues such as the use of energy, land and water, greenhouse gas emissions, environmental footprints, products lifespan, or the impact of activities linked to eco-design, repair, reuse and collaboration in consumption. Some indicators on these areas already exist and form part of Eurostat's information system, but their relevance to the CE's goals has yet to be made explicit through their inclusion in the monitoring framework. In other cases, the potential development of new data sources should be evaluated.

A systemic approach will in turn demand the development of new indicators, to incorporate dimensions such as the institutional drivers required for the transition to CE. This involves, among other things, an assessment of the evolution of legal and fiscal enablers and barriers to CE-related innovation, together with the resources and actions put in motion by UE innovation system to that end.

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## 6.2 F2. International trade and the environment: imports of timber in the EU - Encarnación Moral-Pajares, Ángela Andrea Caviades-Conde, Concepción Martínez-Alcalá, Leticia Gallego-Valero

**INTERNATIONAL TRADE AND THE ENVIRONMENT: IMPORTS OF TIMBER IN THE EU**

**COMERCIO EXTERIOR Y MEDIO AMBIENTE: LAS IMPORTACIONES DE MADERA DE LA UE**

**COMÉRCIO EXTERNO E AMBIENTE: IMPOTAÇÕES DE MADEIRA DA UE**

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ABSTRACT

EU Regulation 995/2010 prohibits the commercialization of illegally harvested timber or products derived from it, in accordance with the EU Action Plan for Forest Law Enforcement, Governance and Trade (FLEGT). The objective of this paper is threefold. First, get to know the EU FLEGT Plan and its possible consequences on imports. Secondly, to analyze the recent evolution of acquisitions in the international market of wood and wood products of the EU countries and to identify their geographical characteristics. Finally, to research the variables conditioning these imports between 2012, one year before the entry into force of the community regulations that prohibit the trade in illegal wood and 2017.

*Key words:* EU, timber, FLEGT, AVA, exports, imports.

RESUMEN

El Reglamento 995/2010 de la UE prohíbe la comercialización de madera aprovechada ilegalmente o de productos derivados de esta, de acuerdo con el Plan de Acción de la UE para la Aplicación de Leyes, Gobernanza y Comercio Forestales (FLEGT**).** El objetivo de este trabajo es triple. En primer lugar, conocer el Plan de FLEGT de la UE y sus posibles consecuencias sobre las importaciones. En segundo lugar, analizar la evolución reciente de las adquisiciones en el mercado internacional de madera y productos de la madera de los países comunitarios e identificar sus características geográficas. Por último, investigar qué variables han condicionado estas importaciones entre

2012, un año antes de la entrada en vigor de la normativa comunitaria que prohíbe el comercio de madera ilegal, y 2017.

*Palabras clave:* UE, comercio exterior, madera, FLEGT, AVA, exportaciones, importaciones.

RESUMO

O Regulamento (CE) n.º 995/2010 proíbe a comercialização de madeira e produtos de madeira extraídos ilegalmente, em conformidade com o Plano de Acção da UE relativo à aplicação da legislação, à governação e ao comércio no sector florestal (FLEGT). O objectivo deste trabalho é triplo. Em primeiro lugar, conhecer o regime FLEGT da UE e as suas possíveis consequências sobre as importações. Em segundo lugar, analisar a evolução recente das aquisições internacionais de madeira e produtos de madeira provenientes de países da UE e identificar as suas características geográficas. Por último, investigar quais as variáveis que condicionaram estas importações entre 2012, um ano antes da entrada em vigor da legislação comunitária que proíbe o comércio de madeira ilegal e 2017.

*Palavras-chave*: UE, madeira, FLEGT, AVA, exportações, importações.

*Clasificación JEL:*.F10, F13, F18, Q56

*Área temática*: Economy, Energy and the Environment: the international challenges

## 1. INTRODUCCIÓN

La deforestación produce efectos negativos sobre el medio ambiente, con consecuencias económicas y sociales (Laurance, 1999). Los bosques albergan más de tres cuartas partes de la biodiversidad terrestre mundial, influyen en el clima, regulan el caudal de los ríos y proveen una amplia gama de productos maderables y no maderables, siendo particularmente importantes para cientos de millones de moradores de las zonas rurales, entre los que se cuentan muchas de las personas más pobres del mundo. El informe de las FAO sobre el estado de los bosques en el mundo de 2018 concluye que los recursos forestales representan una fuente de alimentos, medicinas y combustible para más de mil millones de personas. Además, ayudan a responder al cambio climático y proteger los suelos y el agua,

En respuesta a las preocupaciones globales sobre los impactos de la tala y el comercio ilegal, la Comisión Europea adoptó en 2003 el Plan de Acción de la UE para la Aplicación de Leyes, Gobernanza y Comercio Forestales (FLEGT**).** El Plan establece un paquete de medidas para influir simultáneamente tanto en la demanda como en la oferta de madera producida sosteniblemente, siendo la herramienta principal de la UE para influir en la mejora de la gestión de los bosques y para fomentar el comercio de madera obtenida legalmente. En 2010 la UE adoptó el Reglamento 995/2010 (en lo sucesivo el EUTR), relativo a la comercialización de la madera, aplicable desde el 3 de marzo de 2013 (Simpson, Lemaître y Whiteman, 2012)

La progresiva liberalización de los flujos de intercambio entre países y el desarrollo de leyes ambientales desde principios de los setenta han justificado una preocupación creciente por analizar los vínculos entre medioambiente y comercio. Los distintos trabajos se encuadran en tres posturas encontradas. Para la OMC (2004) las exigencias ambientales pueden obstaculizar el comercio y utilizarse como instrumento proteccionista. Las prescripciones ambientales pueden dificultar el acceso de las exportaciones de los países menos desarrollados a los mercados de mayor nivel de renta y normas más estrictas para la protección del medio natural (Schoenbaum, 1992). En segundo término, hay trabajos que justifican el desplazamiento de las actividades más contaminantes hacia países de menor desarrollo, de acuerdo con los argumentos tradicionales de Heckscher-Ohlin (H-O), siendo los países más avanzados los que se especializan en la producción de mercancías más respetuosas con los recursos naturales (Cherniwchan, 2017), generando un intercambio ecológicamente desigual entre socios comerciales (Shaper, 2000; Moran et al. 2013; YU, Feng y Hubarek, 2014; Huo y Tao, 2018; Infante-Amate y Krausmann, 2019). Para Poter (1991) y Porter y Van der Linde (1995,) sin embargo, las estrictas regulaciones ambientales activan la innovación, incentivando a las empresas para que adopten métodos de producción y obtengan productos y servicios más verdes, de acuerdo con las exigencias del mercado.

El propósito de esta investigación es triple. En primer lugar, conocer el Plan de FLEGT de la UE y sus posibles consecuencias sobre las importaciones de madera de la UE. En segundo lugar, analizar la evolución reciente de las adquisiciones en el mercado internacional de madera y productos de la madera

de los países comunitarios e identificar sus características geográficas. Por último, investigar qué variables han condicionado la evolución reciente de estas importaciones tras la aprobación del reglamento EUTR. Concretamente se consideran los flujos de comercio incluidos en las partidas arancelarias del capítulo 44 recogidas en el anexo I de dicho Reglamento. Para ello, se utiliza información documental y estadística procedente de la base de datos COMTRADE, la Comisión Europea, EUROSTAT, la FAO, Glogal Forest Watch, Trasparency International y Gooble maps. Los resultados de esta investigación pretenden contribuir a la escasa literatura que analiza cómo las normas internacionales que tratan de favorecer la sostenibilidad de los bosques afectan a los flujos de comercio entre países. Además, permitirán aproximar el efecto del EUTR en las importaciones de madera y productos de la madera de la UE en el pasado reciente.

Este trabajo se estructura en cinco apartados, incluido este de carácter introductorio. En el siguiente se analiza el Plan FLEGT, los Reglamento 2173/2005 y 995/2010 y se detallan los Acuerdos de Voluntarios de Asociación firmados por la UE hasta 2018. El apartado tercero recoge un análisis descriptivo de los flujos de comercio de madera de los países de la UE entre 2012, un año antes de la entrada en vigor del Reglamento EUTR y 2017, último año con información disponible. En el apartado cuarto se hace una revisión de la literatura previa y se formulan las hipótesis a contrastas. El apartado quinto, presenta los resultados del modelo del análisis empírico. Por último, el apartado sexto, refiere brevemente las principales reflexiones que se derivan del estudio realizado.

## 2. PLAN DE ACCIÓN DE LA UE PARA LA APLICACIÓN DE LEYES, GOBERNANZA Y COMERCIO FORESTALES

Desde finales de la década de los noventa del siglo XX el Programa de Acción sobro los bosques de los ministros del G8, señala la tala ilegal y el comercio asociado como un grave problema de la comunidad internacional, con importantes consecuencias económicas sociales y ambientales (Banco mundial, 2002). Aunque no existe una definición única de la tala ilegal, para Brack (2003) y Smith (2002), esta se produce cuando la madera se extrae, transporta, compra o vende violando las leyes nacionales que regulan estas actividades. Para la Comisión Europea (2007 )el concepto de madera legal incluye: (i) concesión y cumplimiento de los derechos de tala de madera dentro de los límites legalmente establecidos; (ii) cumplimiento de los requisitos relativos a la gestión forestal, incluida la legislación pertinente en materia de medio ambiente, trabajo y bienestar de la comunidad; (iii) cumplimiento de los requisitos relativos a los impuestos, derechos de importación y exportación, cánones y cánones directamente relacionados con la tala y el comercio de madera; (iv) respeto de los derechos de tenencia o uso de la tierra y los recursos que puedan verse afectados por los derechos de aprovechamiento maderero, cuando existan, y (v) cumplimiento de los requisitos de los procedimientos comerciales y de exportación (Ministerio Federal de Cooperación Económica y Desarrollo,2007) .

En la Cumbre Mundial sobre desarrollo sostenible de 2002, celebrada en Johannesburgo, la Comisión Europea se compromete a combatir la tala ilegal

y el comercio de los productos asociados. Este compromiso determina que en mayo de 2003 la UE adopte el Plan FLEGT (Forest Law Enforcement, Governane and Trade) (en español, Aplicicación de las leyes gobernanza y comercio forestal). En esta línea, en 2008 el Congreso de Estados Unidos aprueba la enmienda a la Ley Lacey, prohibiendo la comercialización de plantas y productos derivados (incluyendo madera y productos maderables) de origen ilegal (Gan, Cashore, y Stone, MW, 2013; Prestemon, 2015). En 2010, Suiza, aprueba la Ordenanza de la declaración de madera y productos madereros (Ordonnance sur la Declaration Concernant le Bois et les Produits en Bois), que obliga a quién venda madera o productos de madera a informar sobre las especies usadas en los productos regulados, especificando si las especies están o no en la lista del CITES, y el lugar de extracción (Noguerón, y Laestadius, 2012). Dicha Ley no exige la legalidad de la madera, pero sí que las empresas que introducen madera y/o productos de la madera en el mercado proporcionen los nombres comerciales (así como los nombres científicos, previa solicitud) y los países donde se realiza el aprovechamiento de la madera que se comercializa. En Australia, la Ley "*Illegal Logging Prohibition Act 2012"*, cubre tanto la madera nacional como la importada, prohibiendo la importación y uso de madera aprovechada ilegalmente y exigiendo que las empresas importadoras apliquen la diligencia debida (Dormontt et al., 2015). Más recientemente, en mayo de 2017 entra en vigor la "Ley de la madera limpia" de Japón para restringir el acceso de la madera extraída ilegalmente a su mercado. Un denominador común para estas iniciativas es que son planteadas por los países que consumen madera y no por los que la produce, con el objetivo general de promover el manejo forestal sostenible (MFS) (Hansen y Treue, 2008; Leipold, Sotirov, Frei, y Winkel, 2016).

El Plan de acción FLEGT tiene como objetivo general promover el control de la producción ilegal de madera y la buena gobernanza forestal, garantizando que las maderas importadas en Europa cumplan con los requisitos legales de las leyes forestales de los países en los que la madera se produce (Comisión Europea, 2007b; Dooley y Ozinga, 2011). Para lograr este objetivo, la UE establece Acuerdos de Asociación Voluntaria (AVA) con países exportadores de madera. Los AVA deben desarrollarse a través de un proceso de gobernanza inclusivo de las partes interesadas e identificar medidas para controlar la producción y el comercio ilegal de madera de exportación (Freerk y Elands, 2012).

El Reglamento (UE) 2173/2005 de 20 de diciembre de 2005 y el Reglamento (CE) 1024/2008 de 17 de octubre de 2008 facultan a la Comisión Europea para firmar Acuerdos de Asociación Voluntaria con los países productores de madera. Aunque la decisión de negociar estos acuerdos es voluntaria, una vez firmados, son jurídicamente vinculantes. Las primeras negociaciones sobre estos acuerdos comenzaron con Ghana y Malasia en 2006, siendo Ghana el primer país en concluir un acuerdo de este tipo. Hasta 2018, la UE ha firmado con siete países un AVA y está desarrollando los sistemas necesarios para controlar, verificar y licenciar la madera legal. Ocho países más están en negociaciones con la UE y dos, Myanmar y China, han expresado interés en recibir más información sobre este proceso, tal y como recoge el cuadro 1.

CUADRO 1. SITUACIÓN DE LOS ACUERDOS DE ASOCIACIÓN VOLUNTARIA DE LA UE.

| Acuerdos firmados | Acuerdos en negociación | Conversaciones con la UE |
|---|---|---|
| Camerún (06-04-2011)[1]<br>Ghana (19-03-2010)<br>Indonesia (20-05-2014)<br>Liberia (19-07-2012)<br>República Centroafricana (20-05-2011)<br>República del Congo (6-04-2011)<br>Vietnan (3-07-2018) | Côte d´Ivoire<br>Gabón<br>Guayana<br>Honduras<br>Laos<br>Malasia<br>República Democrática Del Congo<br>Tailandia | Myanmar<br>China |

1. Publicación del acuerdo en el diario oficial de la UE.
Fuente: EU FLEGT.

El Reglamento EUTR, relativo a la comercialización de la madera, aplicable desde el 3 de marzo de 2013, prohíbe la comercialización en el mercado de la UE de madera aprovechada ilegalmente y de productos derivados de esa madera, y proporciona la lista de los productos que abarca dicho reglamento. Los Estados miembros de la UE son responsables de la aplicación del reglamento, y disponen de autoridades competentes designadas que se encargan del cumplimiento del mismo. Este reglamento es complementario a los Acuerdos Voluntarios de Asociación, y reconoce que las licencias FLEGT son suficientes para demostrar el origen legal de la madera (Simpson, Lemaître y Whiteman, 2012).

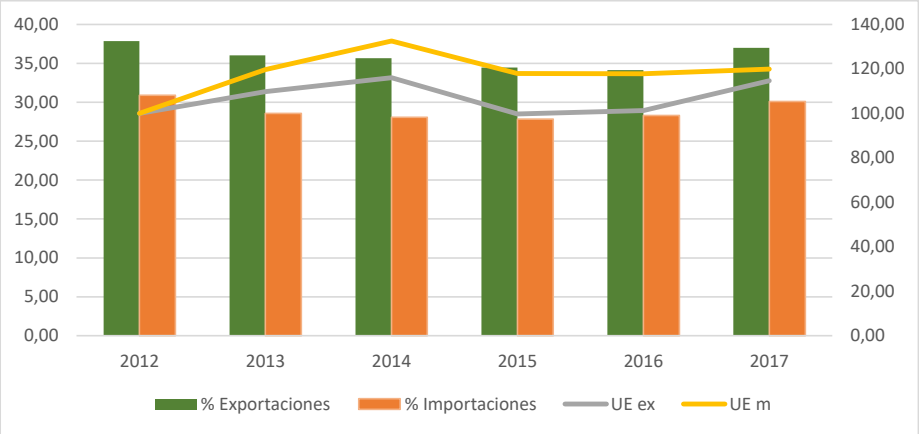
La aplicación de los AVA y el sistema de licencias implica un coste financiero para el país que lo implanta y el desarrollo de capacidades que aseguren la fiabilidad y credibilidad del proceso. A cambio, los productos certificados con la licencia FLEGT disfrutaran de un mejor acceso a los mercados de la UE. Las políticas de contratación tanto públicas como privadas especifican cada vez más el uso de madera legal y la exclusión de madera ilegal o sin identificar (Comisión Europea, 2003; Dooley y Ozinga, 2012).

Las medidas comerciales propuestas se dirigen a luchar contra la producción ilegal de madera basándose en acuerdos bilaterales y voluntarios, y por lo tanto, no plantean problemas de compatibilidad con la OMC, según la Comisión Europea (2007c). Estas medidas se proyectarían sobre objetivos muy precisos – de hecho se harían operativas para cada envío en lugar de operar a nivel de compañía o país – dado que su fin es impedir los flujos comerciales ilegales en lugar de legitimarlos.

## 3. EL COMERCIO DE MADERA EN LA UE

El comercio de madera es importante en la UE. Las exportaciones de madera y productos de madera ascendieron a más de 37.000 millones de dólares en 2012, representando un 37,85% del total mundial, según COMTRADE. Paralelamente, las importaciones sumaron 31.613 millones de dólares, un 30,89%.

GRÁFICO 1. PARTICIPACIÓN DE LA UE EN LA EXPORTACIONES E IMPORTACIONES MUNDIALES DE MADERA Y PRODUCTOS DE LA MADERA Y EVOLUCIÓN DE ESTOS FLUJOS DE COMERCIO ENTRE 2012 Y 2017.

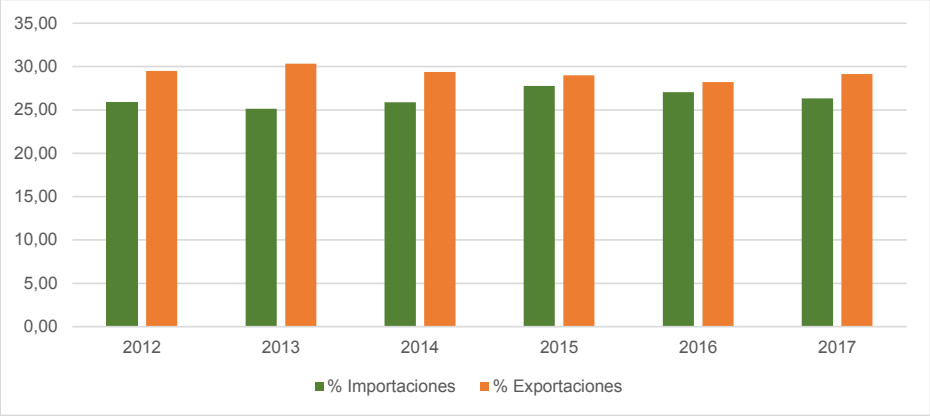



Fuente: COMTRADE.

Entre 2012 y 2017, los flujos de comercio mantienen una dinámica creciente, más intensas por el lado de las compras que por el de las ventas, incrementando su valor en un 19,96% y un 14,70%, respectivamente, tal y como refleja el gráfico 1. En 2017, los 28 socios de la UE son origen de más del 37% de las exportaciones que tienen lugar en todo el mundo de madera y productos de la madera, siendo destino del 30,10% del total de las importaciones, registrando un saldo positivo en sus intercambios con terceros países, que asciende a más de 6.100 millones de dólares.

En el conjunto de la UE, el comercio intracomunitario es mayoritario, representando un 70,86% de las exportaciones y un 73,65% de las importaciones de madera y productos de la madera en 2017, según EUROSTAT. Parte del comercio entre socios puede corresponder a madera o productos de la madera inicialmente importados a la UE. Los flujos registrados con terceros países han mantenido una tendencia creciente en los últimos cinco años, ascendiendo a 26.626,05 millones euros el valor de los intercambios con socios no comunitarios al final del periodo. Entre 2012 y 2017, las exportaciones de la UE a países extracomunitarios alcanzan una tasa media de variación anual acumulada del 4,34% y de un 5,23% las importaciones. En 2017 los países de fuera de la UE son origen 26,35% del total de las compras de madera y productos de la madera (ver gráfico 2).

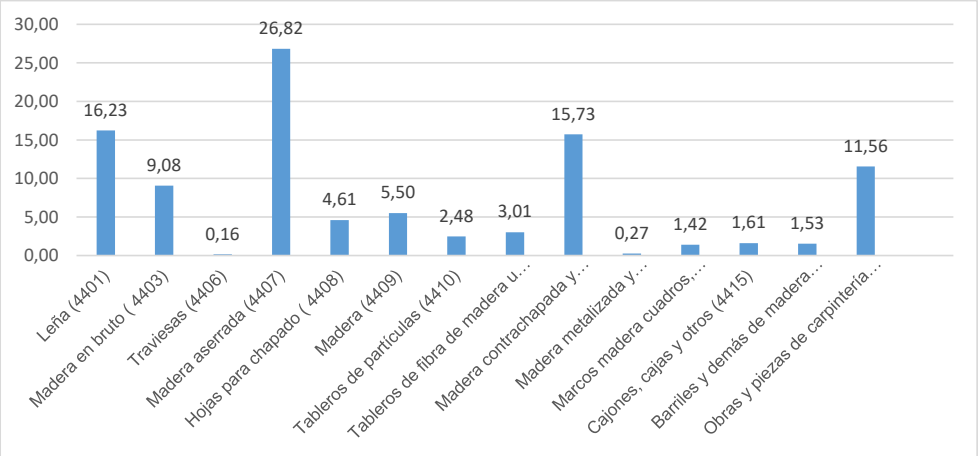
GRÁFICO 2. PARTICIPACIÓN DE LAS EXPORTACIONES E IMPORTACIONES EXTRACOMUNITARIAS EN EL COMERCIO DE MADERA Y PRODUCTOS DE LA MADERA DE LA UE, 2012-2017.




Fuente: COMTRADE.

Por tipo de productos, la madera aserrada es la que más volumen de compras protagoniza, con un 26,82% del total, como recoge el gráfico 3. En una segunda categoría se encuentran las importaciones de leña (16,23%), madera contrachapada y chapada (15,73%), obras y piezas de carpintería para la construcción (11,56%) y madera en bruto (9,08%). El resto de categorías acumulan un 20,59%.

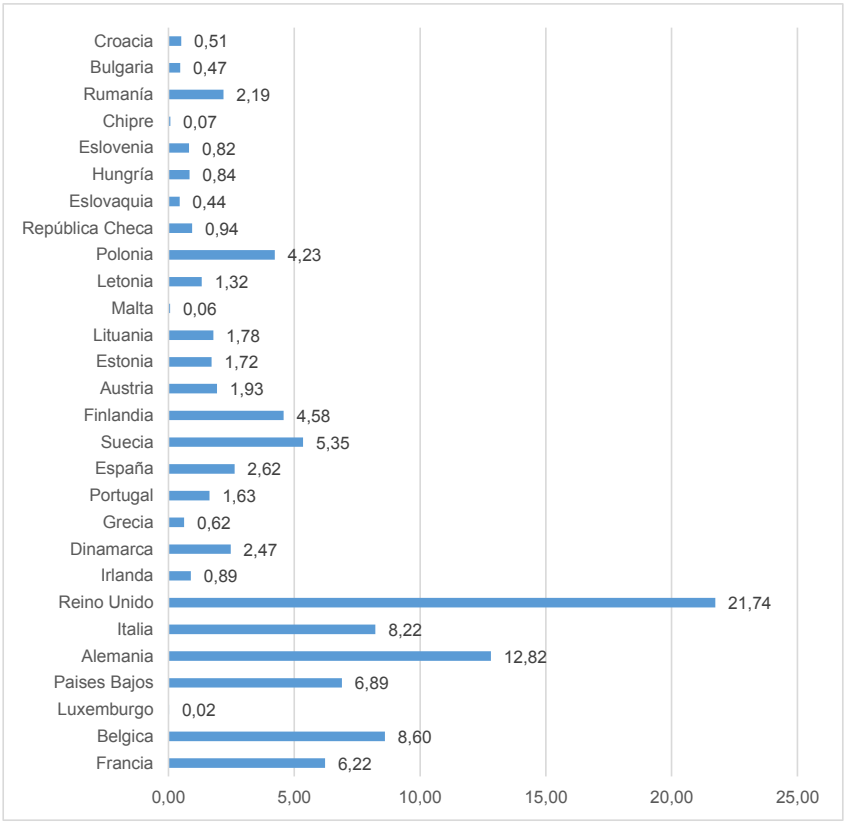
Gráfico 3. Distribución por tipo de productos de las importaciones de madera y productos de la madera de fuera de la ue, 2012-2017.




Fuentes: EUROSTAT.

Las compras en el mercado internacional de los tipos de productos considerados que realizan los socios de la UE no se distribuyen de forma homogénea entre los socios. Tal y como recoge la información del gráfico 4, existe una elevada concentración de este negocio en unos pocos países. En el conjunto de los años que configuran el período temporal de análisis, Reino Unido protagoniza más de una quinta parte del total de adquisiciones realizadas fuera de la UE; le siguen Alemania, con un 12,82%, Bélgica (8,60%) e Italia (8,22%), Países Bajos (6,89%) y Francia (6,22%). Con una cuota entre el 2% y el 6% figuran Suecia, España, Rumanía y Dinamarca. En el resto, dieciséis países, las importaciones extracomunitarias no superan los 1.100 millones de euros, representando menos del 2% del total.

GRÁFICO 4. DISTRIBUCIÓN POR PAÍSES DE LAS IMPORTACIONES DE MADERA Y PRODUCTOS DE LA MADERA DE FUERA DE LA UE, 2012-2017.




Fuentes: EUROSTAT.

El origen de las importaciones extracomunitarias registra una estructura poco diversificada, tal y como muestra la información del cuadro 2. Más de dos quintas partes de las compras proceden de tres grandes mercados: Rusia, China y Estados Unidos.

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CUADRO 2. DISTRIBUCIÓN POR PAÍSES DE LAS IMPORTACIONES EXTRACOMUNITARIAS DE MADERA Y PRODUCTOS DE LA MADERA DE LA UE, 2012-2017.

| PAÍSES | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | VAR 2012-2017 |
|---|---|---|---|---|---|---|---|
| RUSIA | 17,58 | 18,41 | 18,24 | 16,29 | 17,12 | 18,26 | 6,03 |
| CHINA | 15,81 | 14,10 | 13,84 | 14,00 | 12,45 | 12,10 | -0,25 |
| ESTADOS UNIDOS | 10,18 | 11,35 | 13,28 | 15,22 | 15,13 | 15,03 | 13,77 |
| UCRANIA | 5,98 | 6,33 | 7,08 | 7,34 | 7,96 | 7,76 | 10,87 |
| NORUEGA | 4,77 | 5,39 | 5,40 | 5,30 | 5,09 | 5,43 | 8,01 |
| BRASIL | 5,77 | 5,06 | 5,12 | 5,39 | 4,41 | 4,54 | 0,27 |
| CANADÁ | 4,94 | 6,00 | 4,30 | 4,30 | 4,33 | 4,07 | 1,23 |
| BIELORRUSIA | 2,92 | 3,19 | 4,09 | 4,17 | 5,13 | 6,70 | 24,20 |
| INDONESIA[1] | 4,50 | 3,87 | 3,79 | 4,25 | 4,10 | 4,00 | 2,77 |
| SUIZA | 4,74 | 4,55 | 4,38 | 3,82 | 3,66 | 3,52 | -0,85 |
| MALASIA | 4,48 | 3,88 | 3,60 | 3,51 | 3,09 | 2,94 | -3,31 |
| CAMERÚN[1] | 3,52 | 2,95 | 2,68 | 2,71 | 3,03 | 2,33 | -3,07 |
| BOSNIA-HERZEGOVINA | 2,07 | 2,55 | 2,57 | 2,40 | 2,60 | 2,59 | 10,05 |
| GABÓN | 1,79 | 1,88 | 1,67 | 1,67 | 1,96 | 1,67 | 3,77 |
| CHILE | 1,14 | 0,90 | 1,07 | 1,09 | 1,01 | 1,00 | 2,53 |
| SERBIA | 0,88 | 1,05 | 1,13 | 0,96 | 1,03 | 1,05 | 9,04 |
| URUGUAY | 1,24 | 1,24 | 0,85 | 0,85 | 1,05 | 0,84 | -2,65 |
| COSTA DE MARFIL | 1,25 | 1,08 | 1,09 | 0,96 | 0,83 | 0,64 | -7,88 |
| CONGO[1] | 0,68 | 0,83 | 0,75 | 0,74 | 0,83 | 0,70 | 5,67 |
| TURQUÍA | 0,50 | 0,48 | 0,64 | 0,66 | 0,67 | 0,73 | 13,54 |
| CONGO, REP. DEM. | 0,54 | 0,55 | 0,37 | 0,44 | 0,45 | 0,26 | -8,82 |
| GHANA[1] | 0,52 | 0,44 | 0,40 | 0,31 | 0,30 | 0,26 | -8,29 |
| NUEVA ZELANDA | 0,17 | 0,10 | 0,31 | 0,30 | 0,36 | 0,42 | 26,79 |
| VIETNAM[1] | 0,28 | 0,30 | 0,25 | 0,26 | 0,24 | 0,23 | 1,32 |
| SUDÁFRICA | 0,32 | 0,14 | 0,16 | 0,22 | 0,36 | 0,21 | -3,66 |
| MYANMAR | 0,06 | 0,22 | 0,18 | 0,22 | 0,34 | 0,29 | 44,36 |
| INDIA | 0,27 | 0,26 | 0,25 | 0,24 | 0,17 | 0,15 | -5,68 |
| ECUADOR | 0,18 | 0,16 | 0,14 | 0,20 | 0,20 | 0,16 | 2,81 |
| TAILANDIA | 0,30 | 0,18 | 0,22 | 0,13 | 0,13 | 0,08 | -18,30 |
| MARRUECOS | 0,19 | 0,12 | 0,10 | 0,09 | 0,14 | 0,21 | 6,97 |
| PERÚ | 0,13 | 0,11 | 0,12 | 0,15 | 0,12 | 0,12 | 2,73 |
| GUINEA ECUATORIAL | 0,15 | 0,14 | 0,13 | 0,12 | 0,11 | 0,10 | -3,13 |
| AUSTRALIA | 0,09 | 0,11 | 0,05 | 0,06 | 0,11 | 0,12 | 12,92 |
| BOLIVIA | 0,19 | 0,15 | 0,11 | 0,11 | 0,11 | 0,10 | -7,75 |
| ALBANIA | 0,14 | 0,13 | 0,11 | 0,12 | 0,09 | 0,10 | -1,32 |
| R. CENTROAFRICANA[1] | 0,12 | 0,09 | 0,07 | 0,12 | 0,14 | 0,07 | -5,73 |
| SURINAM | 0,07 | 0,10 | 0,10 | 0,11 | 0,12 | 0,08 | 9,20 |
| LIBERIA[1] | 0,14 | 0,06 | 0,03 | 0,03 | 0,02 | 0,01 | -34,79 |
| RESTO DEL MUNDO | 1,28 | 1,40 | 1,24 | 1,09 | 1,02 | 1,15 | 3,01 |
| TOTAL | 100,00 | 100,00 | 100,00 | 100,00 | 100,00 | 100,00 | 5,23 |

[1] Países que tiene firmado un AVA con la UE.

Fuentes: EUROSTAT.

En una segunda categoría se identifican quince economías muy heterogéneas, localizadas en cuatro continentes: Europa, África, América y Asia, que acumulan en conjunto un 50% del total. El resto de socios comerciales extracomunitarios mantienen un escaso peso, con una cuota anual inferior al 1% en todos los años. La dinámica de estos mercados como oferentes de madera y productos de la madera a los países de la UE entre 2012 y 2017 es muy dispar, pues mientras que las importaciones procedentes de Bielorrusia, Myanmar o Nueva Zelanda presentan tasas anuales de variación media superiores al 20%, otros países reducen el valor de sus ventas, como ocurre con cuatro de los países que han firmado un AVA: Camerún, Ghana, la República Centroafricana, y Liberia. En los apartados siguientes se trata de comprobar qué factores han influido en esta dinámica.

## 4. MARCO TEÓRICO E HIPÓTESIS A CONTRASTAR

El Reglamento EUTR de la UE establece la prohibición de introducir en el mercado madera o productos de la madera aprovechados ilegalmente a partir de marzo de 2003. Una exigencia que puede condicionar el origen geográfico de las importaciones de madera procedentes de mercados extracomunitarios. La tala ilegal implica violar las leyes vigentes en el lugar de explotación y está estrechamente asociada a la corrupción y los conflictos por los derechos de propiedad (Ministerio Federal de Cooperación Económica de Alemania, 2007). La falta de rigurosidad y control sobre la actividad forestal en determinados países puede conllevar riesgos para los importadores de la UE, ante la dificultad de demostrar la trazabilidad de la cadena de custodia de la madera. El artículo 19 del Reglamento 995/2010, determina que los países deben fijar el régimen de sanciones aplicable en caso de incumplimiento de las disposiciones que fija la norma, que han de ser efectivas, proporcionadas y disuasorias.

El Article XX of the General Agreement on Tariffs and Trade (GATT), permite que los gobiernos nacionales pueden establecer medidas que evitan el deterioro del entorno natural, sin que ello suponga la discriminación con respecto a terceros (Gaines, 2001). Una realidad que plenamente se cumple en el Reglamento 995/2010, que obliga tanto a los comerciantes y productores de madera de la UE como a los agentes importadores. No obstante, para la OMC (2004) las normas ambientales aplicadas por algunos países podrían ser inadecuadas, y causar un costo económico y social injustificado a los oferentes extranjeros en particular a los que proceden de economías en desarrollo, al obstaculizar sus exportaciones. Además, las prohibiciones de exportación pueden ser una manera poco adecuada de resolver los problemas ambientales relacionados con los bosques porque inducen un mayor consumo interno al disminuir el precio interno de la madera (Braga, 1992; Gillis, 1988).

El compromiso de las instituciones comunitarias en contra de la madera ilegal justifica declaraciones como la realizada por la Oficina Federal de Agricultura y Alimentación – BLE de Alemania, sobre el alto riesgo de las importaciones de teca procedentes de Myanmar[1] o la del grupo de Expertos FLEGT y EUTR de la Unión Europea, en diciembre de 2018, sobre la necesidad de que los agentes que importen madera de la amazonia brasileña deben tomar medidas de

[1] Ver https://www.ble.de/SharedDocs/Pressemitteilungen/EN/2018/180724_Myanmar.html

mitigación de riesgo apropiadas, no basando el resultado de sus análisis de riesgo únicamente en controles documentales sino en verificaciones factuales realizadas por terceras partes[2].

Los argumentos referidos justifican una desviación de comercio a favor de países que cuentan con instituciones solventes, capaces minimizar el riesgo de la tala ilegal, de acuerdo con Borsky, Leiter y Pfaffermayr (2018). Paralelamente, se produciría la reducción de las importaciones procedentes de países con políticas forestales menos rigurosas. Lo indicado permite formular la siguiente hipótesis:
H1. La entrada en vigor de la normativa EUTR en la UE ha propiciado las importaciones de madera con origen en países que cuentan con instituciones gubernamentales solventes para el control de la exportación de madera legal.

Para asegurar la legalidad de la madera importada el reglamento exige auditorías independientes periódicas que certifiquen qué sólo se autoriza la producción de madera que cumpla los requisitos legales. Existen dos instituciones no gubernamentales que trabajan en todo el mundo certificando la sostenibilidad ambiental de la explotación y gestión de los bosques: Forest Stewardship Council (FCS) y el Programa de Reconocimiento de Certificación Forestal (PEFC). La certificación implica el inventario forestal, la planificación de la ordenación, la silvicultura, el aprovechamiento, así como las repercusiones ecológicas, económicas y sociales de las actividades forestales. En diferentes casos el establecimiento de sistemas de certificación forestal ha contribuido al cese de la desforestación y a la rehabilitación de ecosistemas naturales (Tricallotis, Gunninghan y Kanowski, 2018; Lewis y Davis, 2015; Cubbage et al. 2010; Kusonyola, Midtgaard, y Klanderud, 2016). Además, la sensibilidad de los gobiernos en favor de la protección de los bosques puede determinar la puesta en marcha de actuaciones dirigidas a la conservación de este recurso natural, invirtiendo en actuaciones dirigidas a evitar la pérdida de masa forestal (Park y Yeo-Chang, 2017; Vadel, DeMiguel y Pemán, 2016).

La apertura comercial de las economías nacionales es un incentivo para acceder y adoptar nuevas fórmulas de producción más ecológicas (OMC, 2018). Cuando un país se integra en la economía mundial, el sector exportador está más expuesto a los requisitos que en materia ambiental imponen los principales importadores. Los productores, mayoritariamente de small-scale, que no operan de acuerdo con las normas son expulsados del mercado (Obidzinsk, 2014; Sanchezi, Hajjar, R., y Kozak, 2018, Nathan et al. 2018). Poter (1991) y Porter y Van der Linde (1995) defienden que los instrumentos basados en el mercado, como los impuestos, los límites de emisión o explotación, desencadena un efecto innovador en las empresas, tal y como evidencian distintos trabajos empíricos (Ambec et al, 2013). Cada vez son más las compañías y consumidores preocupados por el desempeño ambiental de sus proveedores, lo que influye en la probabilidad de ser elegidos como socio comercial, si actúa en favor de la sostenibilidad (Lanoie et al., 2011; Springate-Baginski et al., 2014) Concretamente, en el sector de la madera tropical, la

[2] http://ec.europa.eu/transparency/regexpert/index.cfm?do=groupDetail.groupMeeting&meetingId=5290

sostenibilidad del producto determina significativamente el valor de las exportaciones (Rodrigue y Soumonni, 2014; Bosky, Leiter y Pfaffermayr, 2018).

Las consideraciones referidas permiten formular las siguientes hipótesis:

H2. Las hectáreas certificadas por organismos independientes –FCS y PEFC- en países exportadores mantiene una relación positiva con las importaciones de madera que realiza la UE.

H3. Una menor pérdida de masa forestal en el país exportador condiciona positivamente las importaciones de madera por parte de la UE

Debido a su capacidad explicativa el modelo de gravedad se ha utilizado en la literatura empírica para analizar los flujos de comercio entre países. Tinbergen (1962) introdujo por primera vez el modelo de gravedad tradicional para explicar los flujos comerciales bilaterales con ausencia de impedimentos comerciales discriminatorios. Según la ley de gravedad de Newton, había tres variables explicativas principales en el modelo: la capacidad productiva del país exportador; la demanda del país importador y el costo del transporte, que introduce el efecto de la distancia entre los socios (Anderson, 1979). Se espera que el flujo de comercio esté positivamente relacionado con el nivel de producción y consumo de los países e inversamente vinculado a la distancia entre ellos. Posteriores estudios empíricos han introducido variables adicionales a las que se contemplan en el modelo de gravedad más sencillo. Así, se analiza la influencia de las barreras artificiales al comercio internacional. En este ámbito, los trabajos empíricos consideran, mayoritariamente, si un país pertenece a un acuerdo que incluya preferencias comerciales, que pueden facilitar el comercio bilateral con los países socios socios (Soloaga, y, Winters, A., 1999, 2001; Greenaway y Milne, 2002, Yang y Martinez-Zarzoso,2014; Carrère, 2006).

El modelo de gravedad se ha empleado ampliamente para modelar los flujos de comercio internacional de una amplia variedad de productos manufacturados (Alan, 1984; Chan y Au, 2007), agroalimentarios (Thi Thu Thuong, 2018), del mar (Natale, Borrello, y Motova, 2015) y en el ámbito de los servicios (Keum, 2010; Morley, Rosselló, y Santana-Gallego, 2014). Incluso es válido para explicar motivaciones más específicas, como el tema de la presente investigación, a saber, el comercio internacional de madera (Houghton, y Naughton, 2017; Borsky, Leiter y Pfaffermayr, 2018). Teniendo en cuenta las características del sector analizado y los resultados de investigaciones precedentes (Manninen, 2014; Hurmekoski, Hetemäki, y Linden, 2015), se considera que la variable que mejor puede aproximar la evolución de la demanda de madera por parte de la UE es la trayectoria seguida por el sector de la construcción. Por otra parte, la capacidad de producción del país exportador se vincula a las hectáreas forestales explotadas, aproximando su oferta en el mercado internacional a partir de los recursos disponibles (O'Brien y Bringezu, 2018; Morland, Schier, Janzen, y Weimar; 2018)

La adaptación de un modelo de gravedad para explicar las importaciones de madera la UE entre 2012 y 1997 permite plantear las siguientes hipótesis:

H4. La demanda de madera en la UE determina positivamente sus importaciones.

H5. La capacidad de producir madera por parte de un país extracomunitario influye en las importaciones de madera de la UE.

H6. La distancia entre el país exportador y la UE afecta negativamente a las importaciones de madera.

H.7. Que exista un acuerdo comercial entre el país exportador y la UE condiciona la importación de madera.

## 5. DETERMINANTES DE LAS IMPORTACIONES DE MADERA Y PRODUCTOS DE LA MADERA EN LA UE

### 5.1 MATERIALES Y MÉTODO

El objetivo de nuestro análisis es evaluar cuáles son los posibles determinantes de las importaciones de madera y productos de la madera de la UE procedentes de países extracomunitarios en los últimos años, tras la aplicación del Reglamento EUTR, haciendo un análisis detallado de las variables y probando la relación entre las independientes y la dependiente. Cabe señalar que la información registrada en las estadísticas oficiales es en muchos casos incompleta o se basa en estimaciones, lo que da lugar a medidas sesgadas de la situación real. En particular, existen brechas para variables particulares y países. Nuestra muestra final incluye datos de 37 economías, para el período 2012-2017. Se llevó a cabo un análisis de datos del panel, de acuerdo con Wooldridge, (2010). Conviene tener en cuenta las siguientes aclaraciones**:**

a.) Los países extracomunitarios considerados son Rusia, China, Estados Unidos, Ucrania, Noruega, Brasil, Canadá, Bielorrusia, Indonesia, Suiza, Malasia, Camerún, Bosnia-Herzegovina, Gabón, Chile, Serbia, Uruguay, Costa de Marfil, Congo, Turquía, República Democrática del Congo, Ghana, Nueva Zelanda, Vietnam, Sudáfrica, Myanmar, India, Ecuador, Tailandia, Marruecos, Perú, Guinea Ecuatorial, Australia, Bolivia, Albania, República Centro Africana, Surinam y Liberia. Países que concentran más del 98% de las importaciones de madera y productos de la madera de la UE entre 2012 y 2017.

b.) La muestra contiene datos durante 6 años consecutivos, que cubren el período 2012-2017. El período de tiempo en estudio es determinado por la entrada en vigor del EUTR en marzo de 2013.

c.) La variable dependiente es el volumen de importaciones que protagonizan la UE de madera y productos de la madera, incluidos en el capítulo 44 de la Nomenclatura Combinada, tal y como establece el Anexo del Reglamento EUTR. Concretamente, se consideran las siguientes partidas y subpartidas: 4401 (Leña), 4403 (Madera en bruto), 4406 (Traviesas), 4407 (Madera aserrada o desbastada), 4408 (Hojas para chapado), 4409 (Madera) 4410 (Tableros de partículas), 4411 (Tableros de fibra), 4412 (Madera contrachapada) 44130000 (Madera densificada),

441400 (Marcos de madera), 4415 (Cajones cajas, etc.), 44160000 (Barriles, cubas, etc.), 4418 (Obras y piezas de carpintería para construcción). La información procede de EUROSTAT.

d.) El modelo estudia un total de 7 variables independientes, cuya descripción, fuente y signo esperado se encuentran en el cuadro 3. Estas variables son confirmadas por las hipótesis establecidas en la Sección 2.

CUADRO 3: VARIABLES INDEPENDIENTES UTILIZADAS EN EL ANÁLISIS, FUENTES Y RELACIÓN ESPERADA CON LA DEPENDIENTE.

| *Variable* | *Descripción* | *Fuente* | *Signo esperado* |
|---|---|---|---|
| *Instituciones gubernamentales solventes* *(CPI)* | Proxy utilizada: Corruption Perceptions Index | Transparency International | + |
| *Hectáreas forestales certificadas* (*HaC)* | Ha certificadas por FCS y PEFC | FAO | + |
| *Pérdida de masa forestal* *(PMF)* | Proxy utilizada: Porcentaje de pérdida de masa forestal | Global Forest Watch | - |
| *Demanda de madera en la UE* *(C)* | Proxy: VAB del sector de la Construcción en la UE | EUROSTAT | + |
| *Oferta de madera en el país i* *(PF)* | Hectáreas forestales en el país i | FAO | + |
| *Distancia* *(D)* | Distancia en Km entre la capital del país i y Bruselas | Google maps | - |
| *Acuerdo o Sistema de Preferencias Generalizadas con la UE* *(Ac)* | Dummy: Acuerdo de asociación con la UE o Sistema de referencias Generalizadas de la UE con el país i en el momento t | Parlamento Europeo | + |

Fuente: Elaboración propia.

Comprobar la posible asociación existente entre las importaciones de madera de la UE procedente de los distintos países extracomunitarios y la evolución de

las distintas variables referidas requiere someter a contraste la siguiente ecuación:

$$X_{it} = v_i + \alpha_1 CPI_{it} + \alpha_2 HaC_{it} - \alpha_3 PMF_{it} + \alpha_4 C_{UEt} + \alpha_5 PF_{it} - \alpha_6 D + \alpha_7 Ac_{it} + e_{it}$$

Donde:

$X_{it}$ : Importaciones de la UE procedentes del país i en el momento t.

$CPI_{it}$: índice de transparencia en el país i en el momento t

$HaC_{it}$: Hectáreas certificadas en el país i en el momento t

$PMF_{it}$: Pérdida de masa forestal en el país i en el momento t

$C_{UEt}$: VAB del sector de la construcción en la UE en el momento t

$PF_{it}$: Hectáreas dedicadas a la producción forestal en el país i en el momento t

$D_{it}$: Distancia desde la capital del país i a Bruselas

$Ac_{it}$: Dummy: acuerdo de asociación con la UE o Sistema de Preferencias Generalizadas de la UE con el país i en el momento t

$\alpha_1, \alpha_2, \alpha_3, \alpha_4, \alpha_5, \alpha_6, \alpha_7,$: coeficientes estimados

Esta relación se completa con una constante, $v_i$, que recoge otros efectos exógenos no incluidos, y el error, $e_{it}$.

Se ha optado por aplicar la metodología de datos de panel para capturar la influencia de variables no medidas que pueden explicar la variación entre países. Las variables se presentan en logaritmos, formulando una secuencia de modelos econométricos hasta alcanzar el óptimo.

La disponibilidad de series temporales para cada una de las variables y unidades muestrales (países), así como la posible presencia de efectos individuales no observables, aconsejan la utilización de técnicas econométricas de datos de panel (Baltagi, 2005). Se trata de una combinación de análisis de corte transversal y de serie temporal, al considerar unidades específicas analizadas y permitir un seguimiento de las observaciones a lo largo del tiempo, controlando la heterogeneidad individual inobservable. Efectivamente, cada país es heterogéneo debido básicamente a las diferencias geográficas, históricas, políticas y económicas, factores específicos, que pueden estar

incidiendo en las importaciones de madera y productos de la madera que realiza la UE y que son difíciles de medir. Otras ventajas que aporta esta técnica son: reducir la colinealidad entre variables, conseguir más grados de libertad y más eficiencia, estudiar mejor las dinámicas de ajuste, identificar y medir efectos que las series temporales o las secciones cruzadas no detectan, construir y contrastar modelos más complejos y eliminar o reducir sesgos en los resultados por la agregación de la información (Baltagi, 2005). No obstante, entre los inconvenientes señalamos: problemas en el diseño y obtención de los datos, limitaciones causadas por series de tiempo reducidas y dependencia de corte transversal.

### 5.2 Resultados

En primer lugar, se realiza un análisis descriptivo de las variables examinadas, que se muestra en el cuadro 4. Se observa un elevado grado de dispersión de los datos respecto a la media para la variable dependiente y dos de las independientes, que se corresponden con las importaciones de madera y productos de la madera (X), la producción forestal (PF) y las hectáreas certificadas (HaC), respectivamente. Para esta última variable se registra un valor de 0 para determinados países como: Albania, República Democrática del Congo, Costa de Marfil, Guinea Ecuatorial, Marruecos, Myanmar y República Centroafricana. El resto de variables presenta un comportamiento más uniforme en cuanto a variabilidad, destacando la construcción (C).

Cuadro 4: Estadisticas descriptivas de las importaciones de madera y productos de la madera y las variables independientes entre 2012 y 2017

| Variables | Obs | Mean | Std. Dev. | Coef. Var. | Min | Max |
|---|---|---|---|---|---|---|
| X | 222 | 239637.3 | 377488.3 | 1.57524851 | 4469.85 | 1854815 |
| C | 222 | 685725.8 | 30741.63 | 0.04483079 | 647466.6 | 736689.8 |
| PF | 222 | 25419.65 | 69155.38 | 2.72054808 | 39 | 418912 |
| HaC | 222 | 8561.995 | 27765.64 | 3.24289374 | 0 | 178895 |
| D | 222 | 6980.459 | 4236.715 | 0.60693931 | 670 | 18711 |
| AC | 222 | 0.7432432 | 0.4378313 | 0.58908215 | 0 | 1 |
| PMF | 222 | 0.5214457 | 0.3981418 | 0.76353453 | 0.0538991 | 1.784667 |
| CPI | 222 | 44.13514 | 20.38031 | 0.4617706 | 15 | 91 |

Fuente: Elaboración propia.

El cuadro 5 muestra los resultados de las estimaciones del modelo de regresión, de Errores Estándar Corregidos para Panel (PCSE, por sus siglas en inglés). El modelo contiene información de 38 países, con un total de 222 observaciones para el periodo 2012-2017.

El proceso seguido para seleccionarlo es el que se describe a continuación. Primero, se estima la regresión agrupada (*Pooled OLS*) y se compara con el de efectos aleatorios (*Random effects*). Para decidir entre los dos se implementa la prueba del Multiplicador de Lagrange para efectos aleatorios de Breusch y Pagan, rechazándose la hipótesis de que no hay variaciones entre los países y confirmando la divergencia de las mismas. Adicionalmente, se puede suponer que estas variaciones entre naciones son constantes, deteminando el modelo de efectos fijos (*Fixed effects*). Posteriormente se aplica el test de Hausman

para elegir entre estos dos últimos, el de efectos fijos o aleatorios. El rechazo de la hipótesis nula sugiere que el modelo apropiado es el primero. Otros test aplicados detectan problemas de correlación contemporánea, heteroscedasticidad y autocorrelación de primer orden. Para resolver estos problemas se aplica el modelo PCSE, que es el recomendado para efectos fijos[3].

Los datos que recoge el cuadro 5 permite constatar una relación entre la variable dependiente y la independiente con el signo esperado en los siguientes casos: la construcción, que aproxima la demanda (al 1%,), la distancia entre la UE y el país exportador (al 1%) y el Índice de transparencia (al 5%); confirmando la hipótesis 1, 4 y 6 planteadas. No resultan significas el porcentaje de pérdida de masa forestal, los acuerdos comerciales y las hectáreas de producción forestal certificada. La superficie de producción forestal figura con una escasa influencia, aunque no resulta con el signo esperado. Por tanto, no se confirman las hipótesis 2, 3, 5 y 7.

CUADRO 5. ESTIMACIONES CON DATOS DE PANEL

| | OLS | Random | Fixed | AR1 | PCSE |
|---|---|---|---|---|---|
| Variable dependiente: importaciones de madera y productos de la madera (X) | modelo 1 | modelo 2 | modelo 3 | modelo 4 | modelo 5 |
| C | 0.568 | 1.665*** | 2.217*** | 1.420*** | 2.252*** |
| | (1.280) | (0.444) | (0.430) | (0.512) | (0.367) |
| PF | 0.325*** | 0.385*** | -0.185 | -0.219 | -0.159*** |
| | (0.035) | (0.076) | (0.171) | (0.350) | (0.060) |
| HaC | 0.205*** | 0.049* | -0.010 | -0.037 | -0.016 |
| | (0.021) | (0.027) | (0.029) | (0.049) | (0.016) |
| D | -1.144*** | -0.919*** | 0.000 | 0.000 | -2.717*** |
| | (0.082) | (0.206) | (0.000) | (0.000) | (0.643) |
| AC | -0.589*** | -0.062 | 0.099 | 0.017 | 0.107 |
| | (0.155) | (0.164) | (0.166) | (0.219) | (0.071) |
| PMF | 0.951*** | 0.042 | -0.239 | 0.005 | -0.165 |
| | (0.162) | (0.223) | (0.239) | (0.390) | (0.202) |
| CPI | -0.005 | 0.018*** | 0.021** | 0.008 | 0.024** |
| | (0.003) | (0.006) | (0.008) | (0.009) | (0.010) |
| Constante | 9.568 | -7.619 | -17.861*** | -6.162 | ------- |
| | (17.249) | (6.388) | (5.758) | (4.039) | ------- |
| Observaciones | 222 | 222 | 222 | 185 | 222 |
| $R^2$ | 0.751 | | 0.171 | | 0.998 |
| Número de países | | 37 | 37 | 37 | 37 |
| Errores estándar entre paréntesis | | | | | |
| *** p<0.01, ** p<0.05, * p<0.1 | | | | | |
| PCSE Wald chi2 Wald chi2(43) = 3320000, Prob > chi2 = 0.0000<br>Hausman test Chi2(6) = (b-B)'[(V_b-V_B)^(-1)](b-B) = 67.67<br>Prob>chi2 = 0.0000 | | | | | |

Fuente: Elaboración propia.

Debido a la amplia variedad de maderas y productos de la madera que se han agregado en la variable importación, se ha considerado apropiado replicar el

[3] El efecto temporal no resulta significativo.

modelo para cinco tipos de productos incluidos en este agregado. Cada uno de las categorías de madera y productos de la madera consideradas presentan un peso superior al 9% en el total de las importaciones realizadas por la UE entre 2012 y 2017. En conjunto, los cinco subgrupos considerados suponen el 80% del volumen de compras realizadas por los países de la UE fuera del mercado comunitario, en el periodo temporal analizado.

Cuando las importaciones consideradas son las incluidas en la partida 4401, leña, resultan significativas y con el signo esperado las variables explicativas construcción (al 10%), los acuerdos comerciales con la UE (al 5%) y pérdida de masa forestal al (5%). Las compras en el mercado extracomunitario de madera en bruto (partida 4403) son explicadas por las hectáreas de producción forestal (al 5%), mantienen una relación inversa con la construcción (al 1%) y el índice de transparencia (al 10%) y positiva con la distancia (al 1%). La importación de madera aserrada (partida 4407) depende positivamente de la construcción (al 5%) y del índice de transparencia (al 1%); las hectáreas de producción forestal (al 1%) y la superficie de producción certificada (al 1%) no mantiene una relación directa.

El segundo grupo de productos importados al que se ha aplicado el modelo se caracterizan por presentar un mayor grado de elaboración, incluyendo las partidas arancelarias 4412 (madera contrachapada, madera chapada y madera estratificada similar) y 4418 (obras y piezas de carpintería para construcción). La importación de la partida 4412 está determinada por la mayoría de las variables consideradas (al 1%). Mantiene una influencia minoritaria el índice de transparencia y no resulta significativa las hectáreas de producción certificada. Las compras incluidas en la partida 4418 están subordinadas a la construcción (al 1%) y mantienen una relación inversa y significativa con la distancia (al 5%); la superficie de producción certificada presenta un coeficiente próximo a cero y signo contrario, resultando significativa (al 5%).

Los resultados obtenidos por tipo de productos de la variable dependiente en algunos casos no son coherentes con los del modelo agregado, aunque aportan valiosa información de la tendencia hacia una estrategia de compras de madera legal por parte de los países de las UE, especialmente en el caso de la madera aserrada. Tal y como constatan los datos, la demanda, vinculada al sector de la construcción, y la distancia con el país oferente, son las variables más influyentes, lo que debe ser tenido en cuenta en el diseño de actuaciones que afecten al sector privado, especialmente a la construcción, que traten de influir en la efectividad del Plan de Acción FLEGT para mejorar la gobernanza forestal y el manejo forestal sostenible.

CUADRO 6. ESTIMACIONES CON DATOS DE PANEL (IMPORTACIONES DESAGREGADAS)

| Modelo PCSE (Errores Estándar Corregidos para Panel) | | | | | |
|---|---|---|---|---|---|
| Variable dependiente:<br>Partida de importaciones | 4401 (leña) | 4403 (madera en bruto) | 4407 (madera aserrada) | 4412 (madera contrachapada y chapada) | 4418 (madera para obras y piezas de carpintería) |
| | | | | | |
| C | 3.682* | -7.182*** | 1.394** | 8.985*** | 4.451*** |
| | (2.103) | (2.084) | (0.549) | (1.786) | (1.487) |
| PF | -0.619 | 0.611** | -1.473*** | 3.106*** | -0.601 |
| | (0.509) | (0.255) | (0.489) | (1.139) | (0.534) |
| HaC | 0.075 | -0.056 | -0.068*** | -0.052 | -0.087** |
| | (0.081) | (0.087) | (0.025) | (0.065) | (0.039) |
| D | -4.664 | 12.731*** | -0.439 | -17.893*** | -6.261** |
| | (3.502) | (3.580) | (1.052) | (3.293) | (2.559) |
| AC | 0.878** | -0.970 | 0.074 | 1.265*** | -0.265 |
| | (0.426) | (0.597) | (0.119) | (0.486) | (0.839) |
| PMF | -2.737** | 0.580 | 0.582 | -3.577*** | -0.251 |
| | (1.159) | (0.971) | (0.377) | (0.799) | (0.421) |
| CPI | -0.012 | -0.046* | 0.038*** | -0.074** | -0.007 |
| | (0.036) | (0.027) | (0.011) | (0.029) | (0.028) |
| Observaciones | 222 | 222 | 222 | 222 | 222 |
| $R^2$ | 0.931 | 0.896 | 0.994 | 0.953 | 0.955 |
| Número de países | 37 | 37 | 37 | 37 | 37 |
| Errores estándar entre paréntesis | | | | | |
| *** p<0.01, ** p<0.05, * p<0.1 | | | | | |

Fuente: Elaboración propia.

## 6. CONSIDERACIONES FINALES

EL Reglamento EUTR, aplicable desde marzo de 2013, prohíbe la comercialización en la UE de madera ilegal y productos derivados de este tipo de madera, con el propósito de contribuir a mejorar la gobernanza forestal de los países productores. En las páginas precedentes se ha tratado de analizar qué ha pasado con las compras de este tipo de productos protagonizadas por los países de la UE en el mercado internacional entre 2012 y 2017 y qué

variables han determinado su evolución. Las principales conclusiones obtenidas se detallan a continuación.

1. La UE es un actor principal en el comercio internacional de madera y productos de la madera, destino del 30,10% de las importaciones mundiales en 2017.
2. Aunque el comercio intracomunitario de este tipo de productos es mayoritario, representando en 2017 un 70,86% de las exportaciones y un 73,65% de las importaciones, los flujos mantenidos con terceros países han mantenido una tendencia creciente en los últimos años. Este comercio ha sido más intenso por el lado de las compras que por el de las ventas, determinando un déficit comercial en sus relaciones con terceros.
3. Por tipos de productos, la madera menos elaborada es la que más se importa de terceros países, siendo la aserrada la categoría que mayor volumen concentra, seguida de la leña y madera en bruto. Entre los productos de madera con mayor valor añadido destaca la madera contrachapada, chapada y estratificada y la de obras y piezas de carpintería para la construcción. El resto de mercancías tienen un escaso peso.
4. Las compras en el mercado internacional están protagonizadas por unos pocos países. Reino Unido es el responsable principal, seguido de Alemania, Bélgica, Italia, Países Bajos y Francia. Estas seis economías concentran el 60,39% de las importaciones de madera y productos de la madera procedentes de fuera de la UE en 2017.
5. El origen de las importaciones está, asimismo, muy poco diversificado. En 2017, siete países (Rusia, China, Estados Unidos, Ucrania, Noruega, Brasil, Canadá, Bielorrusia e Indonesia) son los que proveen a la UE de más de tres cuartas partes del total importado. Entre ellos destacan Rusia (18,26%), Estados Unidos (15,03%) y China (12,10%).
6. A excepción del Congo, las economías nacionales que han firmado un Acuerdo de Asociación Voluntaria con la UE no registran aumentos considerables de sus exportaciones al mercado europeo entre 2012 y 2017. Muy al contrario, presentan variaciones anuales medias inferiores al 5% y, en cuatro casos, la evolución registrada es negativa.
7. El conjunto de países que han firmado un AVA pasan de una cuota en las importaciones de madera y productos de la madera del agregado comunitario del 9,64% en 2012 a concentrar un 7,52% en 2017. Lo que cuestiona la capacidad de estos acuerdos para facilitar de forma inmediata el acceso de sus productos al mercado europeo.
8. Las variables que más determinan las importaciones de la UE de madera y productos de la madera procedentes del exterior son el comportamiento del sector de la construcción, condicionante principal de la demanda en el mercado intracomunitario, la distancia del país proveedor y, en menor medida, el nivel de transparencia que ofrecen las instituciones del país oferente, que garantizan la legalidad de los productos exportados. Existen, no obstante, diferencias en función del tipo de producto considerado.
9. Las hectáreas certificadas en el país oferente o la pérdida de masa forestal, dos variables muy vinculadas a la sostenibilidad de los bosques, no resultan significativas en la evolución del total de las importaciones extracomunitarias de la UE.

10. Los acuerdos comerciales que los países han firmado con la UE y que facilitan el acceso de sus productos al mercado, sólo condicionan las importaciones de madera más elaborada, contrachapada y chapada (4412).

Los argumentos referidos cuestionan la capacidad del Plan FLEGT para influir a corto y medio plazo y de forma favorable en las ventas de madera y productos de la madera que los países asociados protagonizan en el mercado de la UE, lo que puede afectar a la disposición de los gobiernos nacionales a la puesta en marcha de las negociaciones de un AVA y, por tanto, a la efectividad del Plan de Acción FLEGT para la mejora de la gestión de los bosques. Se requiere que desde las autoridades competentes se pongan en marcha medidas que impulsen la compra de madera legal y gestionada de forma sostenible por parte del sector privado y, tal y como se propone en la conclusión del informe de evaluación del Plan de Acción FLEGT 2004-2014 (Topper et al., 2016), un cambio en el foco geográfico hacia países sin un AVA y centrarse en coaliciones internacionales si se quiere hacer frente a la tala y el comercio de madera ilegales a nivel mundial.

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## 6.3 F3. FDI-pollution nexus: evidence of OECD countries - Authors: Rafaela Caetano, António Cardoso Marques

*FDI-pollution nexus: evidence of OECD countries*

*Nexus IDE-poluição: evidência para os países da OCDE*

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Abstract

The main purpose of this study was to understand if the FDI has an impact on the CO2 emissions for a panel of 15 OECD countries with annual data from 2005 to 2016, using The Panel Autoregressive Distributed Lag (PARDL) model. This investigation analyzes the impact of the mining FDI, manufacturing FDI and services FDI in the CO2 emissions in addition to the aggregated FDI. According to the results, the increase in the FDI increases the CO2 emissions, which supports the Pollution Haven Hypothesis. The policy-makers should restrict the environmental laws directly related with FDI, regulate the clean FDI and attract more clean FDI as possible.

*Keywords:* Investment, CO2 emissions, FDI, pollution

Resumo

O principal objetivo deste estudo foi perceber se o IDE tem impacto nas emissões de CO2 num painel para 12 países da OCDE com dados anuais desde 2005 até 2016 utilizando o modelo *Panel Autoregressive Distributed Lag* (PARDL). Esta investigação analisa o impacto do IDE do setor da mineração, da manufaturação e dos serviços nas emissões de CO2, em adição ao modelo do IDE agregado. De acordo com os resultados, um aumento do IDE aumenta das emissões de CO2, o que suporta a *Pollution Haven Hypothesis*. Os decisores políticos devem restringir as suas leis ambientais diretamente relacionadas com o IDE, regular o IDE limpo e atrair o máximo de IDE limpo possível.

*Palavras-Chave:* Investimento, emissões de CO2, IDE, poluição

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Is it candidate to the **José Luís Sampedro Prize/Award?** Yes ☒ No ☐

## 1. Introduction

The climate changes are a constant global fighting, but the economic development is a global objective. It is important to the country's economy to achieve a balance. A sustainable development needs a strong and drastic structural change. According to UNESCO, the 2030 Agenda presents 17 objectives to a sustainable development and the climate action is the most important to this investigation. The biggest enemy of climate changes is the CO2 emissions originated from fossil fuel.

The targets established in 2030 Agenda needs to be funded to being reached, and that is the biggest challenge of climate changes. Sources of the investment may be, for example, through the banks, pension funds, insurance companies, however, the FDI is the biggest source of foreign investment. The foreign direct investment has benefits like the creation of higher skilled jobs and the introduction of technology and innovation, for example. (UNCTAD, 2017)

Due to the importance of foreign investments, it could be interesting to analyze if the foreign direct investment (future namely as FDI) had an impact on the pollution, more precisely, in the CO2 emissions.

In this study were used 15 *Organization for Economic Co-operation and Development* (OECD) countries, with annual data from 2005 to 2016. The panel autoregressive distributed lag (ARDL) model was used on the empirical investigation mainly because supports variables with a different order of integration. Through the ARDL model, the main goal of this investigation is to answer the central question: "What is the impact of the inward FDI in the CO2 emissions in the OECD countries?"

The central question was divided into more three sub-questions, with the disaggregated FDI into sector:

- What is the impact of the inward FDI of the mining sector in the CO2 emissions in the OECD countries?
- What is the impact of the inward FDI of the manufacturing sector in the CO2 emissions in the OECD countries?
- What is the impact of the inward FDI of the services sector in the CO2 emissions in the OECD countries?

Given the central question, it was constructed the following hypothesis with aggregated FDI which can be used for mining, manufacturing, and services FDI:

- H1: The FDI have a positive impact in the CO2 emissions in the OECD countries, which supports the Pollution Haven Hypothesis. (see section 2)

This investigation will try to confirm (or not) the truthfulness of the H1 and will try to contribute to the enlargement of the literature, because of the utilization of the FDI by economic sector.

This study is organized as follows: Section 2 presents literature review; Section 3 describes data and methodology; Section 4 presents the results and discussion of the aggregated FDI (Model I); Section 4 presents the results and discussion of the sectoral FDI; and Section 6 concludes.

## 2. Review literature

The literature about FDI phenomenon is quite extensive and is applied about different economic issues. Following Borensztein et al. (2010), the FDI is a driver of the economic growth and, for this, all the economic implication about the phenomenon should be considered by policy-makers.

Some literature suggests that FDI can be related with energy efficiency gains with the transfer of technology and can improve environmental pollution (see, e.g. Hubler and Keller, 2010; Liang, 2009; Eskeland and Harrison, 2003; Letchumanan and Kodama, 2000). For example, Liang (2008) find a negative correlation between FDI and local air pollution in China. The author suggests that FDI could insert new and improved technology. Liu et al., 2017 show that FDI can help in reducing CO2 emissions due to the utilization of advanced clean technology accomplished from the FDI (see, e.g., Tamazian et al., 2009; List and Co, 2000)

Zhang and Zhou, (2016) studied if the FDI led to lower CO2 emissions from China and found that FDI contributes to CO2 emissions reduction. Their findings support the pollution halo hypothesis. The authors also referred that foreign firms can export greener technologies from developed countries to developing countries.

Linkage with the benefits about FDI in the host countries, the Pollution Halo Hypothesis releases that multinational firms diffused their clean technology in the host countries through the modern and eco-friendly technology exportation, this is, the FDI inflows can help the environmental pollution reduction (see, e.g., Kim and Adilov, 2012). Doytch and Uctum, 2016 studied the halo effect hypothesis which supports that the FDI is beneficial to the host countries because of the transfer of clean technology and know-how.

Grossman and Krueger, (1991) rely that some effects can make the FDI-pollution nexus harder to analyze: the scale, technique and composition effects. The scale effect means that FDI can lead an increase in pollution emissions and an increase in the economic activity in the host countries. The technique effect suggests that FDI can have an important role in reducing emissions because foreign firms can transfer modern technologies improving energy efficiency. Lastly, the composition effect defends that FDI can have both positive and negative impacts on the environment. (see, e.g., Jalil & Mahmud, 2009).

Some studies proved that FDI can bring disadvantages to the local pollution through the Pollution Haven Hypothesis (future namely as PHH), this is, the FDI increase CO2 emissions in the host countries (see, e.g., Al-mulali, 2012; Cole and Elliott, 2002; Smarzynska and Wei, 2001). This hypothesis suggests that stringency environmental laws in the developed/source countries deport the polluting industries from the source countries as FDI inflows to the developing/host countries, due to their relaxed environmental laws. The biggest concern about reducing CO2 emissions is global warm. If the polluting industries were moved from developed to developing countries, the CO2 emissions

continue in the same value, and only localization of the emissions was modified. (see, e.g., Copeland and Taylor, 1994; Walter and Ugelow, 1979)

Mihci et al., 2005 conclude that exists a positive relationship between FDI outflows and stringency environmental laws by the developed countries and List et al., (2004) shows that lax environmental laws attract polluting FDI inflows.

Sapkota and Bastola, 2017 found a positive effect between FDI stock and population (this is, CO2 emissions), which indicates that an increase in FDI stock would increase pollution in Latin America, which supports PHH. The authors considered the human capital in their investigation and the results show that pollution is negatively correlated with human capital in low-income countries and is positively correlated in high-income countries, suggesting that the policies for increasing human capital contribute to pollution reduction, especially in low-income countries.

Baek, 2016 found that the FDI can increase the CO2 emissions, *ceteris paribus*, which proved the PHH. Shahbaz et al., 2019 found unidirectional causality from the FDI to CO2 emissions, concluding that FDI inflows have to be regulated to attract just clean FDI that will ensure transfer of green technology and promote renewable sources, through a specialization process converting old and polluting sectors to a new and clean sectors. The companies should introduce new technologies in order that FDI can modify environmental management practices in a context of a sustainable development.

The developing countries need an investment to grow faster and, once that FDI is very related with economic growth, the developing countries should improve and strengthen their environmental regulations.

The FDI-pollution nexus is interesting to analyze for all countries. The global warming problem is a global concern, which means that all the countries have an important role for achieving the objectives.

Abdouli and Hammami, (2017) studied the phenomenon in the developed countries and concluded that the globalization can accelerate structural changes and can promote the developing economies integration. Smarzynska and Wei, (2001) analyze 24 European countries and found that the FDI have a positive impact in CO2 emissions on the host countries, supporting PHH. Lee and Brahmasrene, 2013 found a negative impact between FDI and CO2 emissions on the European Union countries. Hoffmann et al., (2005) do not achieve any causal relationship amongst the FDI and CO2 emissions in the high-income countries, similarly to Atici, (2012) e Lee, (2013).

The reason why these studies have different conclusions about de FDI-pollution nexus is because this varies through different income levels, different economic development or different environmental regulations and the authors apply different empirical methodologies and choose different countries/regions and different periods. (Zhang and Zhou, 2016)

The empirical methodology used to see the impact of the foreign direct investment has in the CO2 emissions differ from author to author. There are two main methodological approaches: panel data estimations and time series

estimations. The majority studies have focused in the multi-country analyses, this is, the panel data models are frequently preferred because they allow to do a simultaneous analysis of the cross-sectional and temporal dimensions. However, some studies have focused on a single country using a time series estimation (see, e.g., Hitam and Borhan, 2012; Lee, 2009; List and Co, 2000) The Granger causality (see, e.g., Hassaballa, 2014; Shahbaz et al., 2013), the generalized method of moments (GMM) (see, e.g., Shahbaz et al., 2019) and ARDL (see, e.g., Kim and Baek (2011) are some of the estimation methods that are more frequently used in this type of investigation.

Doytch and Uctum, 2016 tested the halo effect hypothesis disaggregating the FDI. The authors analyzed the effect of the total FDI, the primary sector FDI, the manufacturing FDI and the tertiary sector FDI on CO2 emissions concluding that the FDI benefit the environment in the rich countries across industries but degrades it in the poor countries, which supports the halo effect in rich countries.

In order to increase the robustness of the model and following Doytch and Narayan (2016), because the author concluded that the impact of the FDI in the energy consumption depends of the sectoral FDI and the income level, in addition to the model with the global FDI, was estimated three models to analyze in detail the disaggregated FDI into mining, manufacturing and total services.

Lastly, once that the conclusions about the FDI-pollution nexus are not consensual, in the present investigation the main goal is to analyze the impact of the FDI in the CO2 emissions in the OCDE countries, dividing the FDI by sector, trying to confirm (or not) the Pollution Haven Hypothesis (or Pollution Halo Hypothesis).

3. Data and methodology

The main goal of this study is observe and analyze the impact of the foreign direct investment (FDI) on the CO2 emissions of a group of OECD countries, namely: Australia, Austria, Estonia, France, Germany, Greece, Hungary, Italy, Japan, Latvia, Netherlands, Poland, Slovak Republic, Turkey, and United Kingdom using annual data from 2005 to 2016. Both the time horizon and countries were chosen given the available data. In the Table 1., the name, definition and source of the raw variables are presented.

TABLE 1: VARIABLES DESCRIPTION

| Variables | Definition | Source |
|---|---|---|
| CO2 | Carbon dioxide emissions in million tones of carbon dioxide | BP statistics |
| FDI | Inward FDI main aggregates in US Dollar | OECD statistics |
| FDIM | Inward FDI of the mining sector in US Dollar | OECD statistics |
| FDIMAN | Inward FDI of the manufacturing sector in US Dollar | OECD statistics |
| FDIS | Inward FDI of the total services sector in US Dollar | OECD statistics |
| E | Primary energy consumption in million tonnes oil equivalente | BP statistics |
| T | Trade, in % of Gross Domestic Product (GDP) | World Bank, WDI |
| CS | Gross fixed capital formation in constant 2010 US$ | World Bank, WDI |
| GDP | Gross Domestic Product in constant 2010 US$ | World Bank, WDI |
| POP | Total population | World Bank, WDI |

The dependent variable will be Carbon dioxide emissions (CO2) as a proxy of pollution. The interest variables will be aggregated FDI in Model I, mining FDI in Model II, manufacturing FDI in Model III and total services FDI in Model IV. The interest variables are divided by models because of the high correlation between them.

The control variables are primary energy consumption (E) and gross fixed capital formation (CS) to a proxy of capital stock following Sapkota and Bastola, 2017, because will minimize omitted variable bias which could improper decrease the effects of the variables in environmental pollution. In their study the authors refer that an increase in the energy consumption can be through of an increase number of capital-intensive industries, which leads to increased pollution and refer that an increase in capital stock (CS) in a production process generally consumes more energy, thus increases pollution. Some studies that do not include the energy consumption in their analysis are likely to suffer from the omitted variable bias and provide misleading results (Baek, 2016). The Trade (T) was used as a proxy of openness trade, because following Sbia et al., 2014 the correlation between trade openness and FDI is positive and with the Granger causality analysis, the author founds that trade openness causes FDI, energy consumption and CO2 emissions. GDP will be used to eliminate percentage of the Trade, and all variables will be transformed into *per capita*, dividing by the total population (POP) to eliminate distortions caused by the population.

In order to analyze the impact of the aggregate and sectoral FDI in the CO2 emissions, both in short and long-run, will be used the autoregressive distributed lag (ARDL) model. This model gives us the dynamic effects of our variables, deals with cointegration and is robust to the variables being

endogenous. The ARDL model specification is the following where “L” means natural logarithms and “D” means first differences. The equation (1) represents the specification of the Model I.

$$LCO2_{it}=\alpha_{1i}+\delta_{1i}TREND+\beta_{1i1}LCO2_{it-1}+\beta_{1i2}FDI_{it}+\beta_{1i3}FDI_{it-1}+ \beta_{1i4}LE_{it}+\beta_{1i5}LE_{it-1}+\beta_{1i6}LT_{it}+\beta_{1i7}LT_{it-1}++\beta_{1i8}LCS_{it}+ +\beta_{1i9}LCS_{it-1}+ \mu_{1it} \quad (1)$$

To explain the dynamic relationships between the variables, the equation (1) was modified to the following specification – equation (2).

$$DLCO2_{it} = \alpha_{2i} + \delta_{2i}TREND + \beta_{2i1}DLFDI_{it} + \beta_{2i2}DLE_{it} + \beta_{2i3}DLT_{it} + \beta_{2i4}DLCS_{it} + \gamma_{2i1}LCO2_{it-1} + \gamma_{2i2}LFDI_{it-1} + \gamma_{2i3}LE_{it-1} + \gamma_{2i4}LT_{it-1} + \gamma_{2i5}LCS_{it-1} + \mu_{2it} \quad (2)$$

The equation (3), (5) and (7) represents the Model II, III and IV, and was replaced to the equation (4), (6) and (8), respectively to explain the variables dynamic relationships.

$$LCO2_{it}=\alpha_{3i}+\delta_{3i}TREND+\beta_{3i1}LCO2_{it-1}+\beta_{3i2}FDIM_{it}+\beta_{3i3}FDI_{it-1}+ \beta_{3i4}LE_{it}+\beta_{3i5}LE_{it-1}+\beta_{3i6}LT_{it}+\beta_{3i7}LT_{it-1}+\beta_{3i8}LCS_{it}+ +\beta_{3i9}LCS_{it-1}+ \mu_{3it} \quad (3)$$

$$DLCO2_{it} = \alpha_{4i} + \delta_{4i}TREND + \beta_{4i1}DLFDIM_{it} + \beta_{4i2}DLE_{it} + \beta_{4i3}DLT_{it} + \beta_{4i4}DLCS_{it} + \gamma_{4i1}LCO2_{it-1} + \gamma_{4i2}LFDIM_{it-1} + \gamma_{4i3}LE_{it-1} + \gamma_{4i4}LT_{it-1} + \gamma_{4i5}LCS_{it-1} + \mu_{4it} \quad (4)$$

$$LCO2_{it}=\alpha_{5i}+\delta_{1i}TREND+\beta_{5i1}LCO2_{it-1}+\beta_{5i2}FDIMAN_{it}+\beta_{5i3}FDI_{it-1}+ \beta_{5i4}LE_{it}+\beta_{5i5}LE_{it-1}+\beta_{5i6}LT_{it}+\beta_{5i7}LT_{it-1}+\beta_{5i8}LCS_{it}+ +\beta_{5i9}LCS_{it-1}+ \mu_{5it} \quad (5)$$

$$DLCO2_{it} = \alpha_{6i} + \delta_{6i}TREND + \beta_{6i1}DLFDIMAN_{it} + \beta_{6i2}DLE_{it} + \beta_{6i3}DLT_{it} + \beta_{6i4}DLCS_{it} + \gamma_{6i1}LCO2_{it-1} + \gamma_{6i2}LFDIMAN_{it-1} + \gamma_{6i3}LE_{it-1} + \gamma_{6i4}LT_{it-1} + \gamma_{6i5}LCS_{it-1} + \mu_{6it} \quad (6)$$

$$LCO2_{it}=\alpha_{7i}+\delta_{7i}TREND+\beta_{7i1}CO2_{it-1}+\beta_{7i2}FDIMS_{it}+\beta_{7i3}FDI_{it-1}+ \beta_{7i4}LE_{it}+\beta_{7i5}LE_{it-1}+\beta_{7i6}LT_{it}+\beta_{7i7}LT_{it-1}+\beta_{7i8}LCS_{it}+ +\beta_{7i9}LCS_{it-1}+ \mu_{7it} \quad (7)$$

$$DLCO2_{it} = \alpha_{8i} + \delta_{8i}TREND + \beta_{8i1}DLFDIS_{it} + \beta_{8i2}DLE_{it} + \beta_{8i3}DLT_{it} + \beta_{8i4}DLCS_{it} + \gamma_{8i1}LCO2_{it-1} + \gamma_{8i2}LFDIS_{it-1} + \gamma_{8i3}LE_{it-1} + \gamma_{8i4}LT_{it-1} + \gamma_{8i5}LCS_{it-1} + \mu_{8it} \quad (8)$$

Table 2., presents the characteristics of the series through the descriptive statistics as well as the results from the cross-section dependence (CD) test. Observing the results from CD test, it is possible to conclude that all variables present cross section dependence.

TABLE 2: DESCRIPTIVE STATISTICS AND CROSS-SECTIONAL DEPENDENCE

| Variables | Descriptive statistics | | | | | Cross section dependence (CD) | | |
|---|---|---|---|---|---|---|---|---|
| | Obs | Mean | Std. Dev. | Min. | Max. | CD-test | Corr | Abs(corr) |
| LCO2 | 180 | -11.755 | 0.457 | -12.616 | -10.849 | 11.90*** | 0.335 | 0.630 |
| LFDI | 180 | -4.837 | 0.953 | -7.144 | -2.471 | 20.95*** | 0.590 | 0.664 |
| LFDIM | 180 | -10.056 | 2.661 | -18.840 | -4.638 | 1.77* | 0.050 | 0.487 |
| LFDIMAN | 180 | -6.440 | 1.001 | -9.564 | -3.615 | 7.79*** | 0.220 | 0.500 |
| LFDIS | 180 | -5.403 | 1.143 | -9.672 | -2.893 | 18.78*** | 0.529 | 0.608 |
| LE | 180 | -12.637 | 0.373 | -13.592 | -12.010 | 9.53*** | 0.268 | 0.628 |
| LT | 180 | 14.558 | 0.602 | 12.995 | 15.900 | 23.32*** | 0.657 | 0.682 |
| LCS | 180 | 8.668 | 0.573 | 7.468 | 9.674 | 8.51*** | 0.240 | 0.425 |
| DLCO2 | 165 | -0.012 | 0.052 | -0.136 | 0.205 | 11.63*** | 0.342 | 0.447 |
| DLFDI | 165 | 0.051 | 0.173 | -0.670 | 0.577 | 17.23*** | 0.507 | 0.556 |
| DLFDIM | 165 | 0.089 | 0.838 | -4.624 | 4.130 | 2.41** | 0.071 | 0.256 |
| DLFDIMAN | 165 | 0.052 | 0.351 | -0.982 | 3.392 | 6.20*** | 0.182 | 0.330 |
| DLFDIS | 165 | 0.078 | 0.333 | -0.589 | 3.456 | 12.80*** | 0.377 | 0.406 |
| DLE | 165 | -0.006 | 0.045 | -0.130 | 0.195 | 15.42*** | 0.454 | 0.478 |
| DLT | 165 | 0.028 | 0.097 | -0.395 | 0.234 | 23.37*** | 0.688 | 0.766 |
| DLCS | 165 | 0.004 | 0.101 | -0.455 | 0.299 | 15.67*** | 0.461 | 0.476 |

Notes: To achieve the results of descriptive statistics and to test the presence of cross section dependence the Stata commands *sum* and *xtcd*, respectively, were used. The CD test has N(0,1) distribution under the H0: cross section independence, ***, **, * denote statistical significance at 1%, 5%, 10% level, respectively.

In Table 3., we can observe the correlation matrices and variance inflation factor (VIF) statistics of the Model I, Model II, Model III and Model IV. The correlation matrix was commonly used to check the degree of correlation that exist between the variables, while the VIF statistics was used to test if there is presence of multicollinearity. In Model I, exists a high correlation between LE and LCO2 and DLE and DLCO2, but it is not a problem given that the high correlation is with the dependent variable. The same happens in the Model II, III and IV with the same variables. In Model I the correlation matrix also gives a high correlation between LT and LFDI, but it is normal because it was used the main aggregated FDI, but also is it not a problem. The lower VIF and mean VIF values prove that multicollinearity is not a problem to our estimation.

TABLE 3: CORELATION MATRICES AND VIF STATISTICS

MODEL I

| | LCO2 | LFDI | LE | LT | LCS | | DLCO2 | DLFDI | DLE | DLT | DLCS |
|---|---|---|---|---|---|---|---|---|---|---|---|
| LCO2 | 1.000 | | | | | DLCO2 | 1.000 | | | | |
| LFDI | 0.428 | 1.000 | | | | DLFDI | 0.040 | 1.000 | | | |
| LE | 0.856 | 0.610 | 1.000 | | | DLE | 0.890 | 0.024 | 1.000 | | |
| LT | 0.440 | 0.820 | 0.719 | 1.000 | | DLT | 0.506 | 0.015 | 0.456 | 1.000 | |
| LCS | 0.545 | 0.419 | 0.793 | 0.574 | 1.000 | DLCS | 0.250 | 0.162 | 0.255 | 0.580 | 1.000 |
| VIF | | 3.17 | 3.85 | 4.05 | 2.81 | | | 1.04 | 1.26 | 1.79 | 1.56 |
| Mean VIF | | | 3.47 | | | | | | 1.41 | | |

MODEL II

| | LCO2 | LFDIM | LE | LT | LCS | | DLCO2 | DLFDIM | DLE | DLT | DLCS |
|---|---|---|---|---|---|---|---|---|---|---|---|
| LCO2 | 1.000 | | | | | DLCO2 | 1.000 | | | | |
| LFDIM | 0.278 | 1.000 | | | | DLFDIM | -0.068 | 1.000 | | | |
| LE | 0.856 | 0.259 | 1.000 | | | DLE | 0.890 | -0.080 | 1.000 | | |
| LT | 0.440 | 0.292 | 0.719 | 1.000 | | DLT | 0.506 | -0.046 | 0.456 | 1.000 | |
| LCS | 0.545 | 0.172 | 0.793 | 0.574 | 1.000 | DLCS | 0.251 | -0.059 | 0.255 | 0.580 | 1.000 |
| VIF | | 1.10 | 3.77 | 2.12 | 2.71 | | | 1.01 | 1.27 | 1.78 | 1.51 |
| Mean VIF | | | 2.43 | | | | | | 1.39 | | |

MODEL III

| | LCO2 | LFDIMAN | LE | LT | LCS | | DLCO2 | DLFDIMAN | DLE | DLT | DLCS |
|---|---|---|---|---|---|---|---|---|---|---|---|
| LCO2 | 1.000 | | | | | DLCO2 | 1.000 | | | | |
| LFDIMAN | 0.393 | 1.000 | | | | DLFDIMAN | -0.069 | 1.000 | | | |
| LE | 0.856 | 0.502 | 1.000 | | | DLE | 0.890 | -0.079 | 1.000 | | |
| LT | 0.440 | 0.622 | 0.719 | 1.000 | | DLT | 0.506 | -0.153 | 0.456 | 1.000 | |
| LCS | 0.545 | 0.349 | 0.793 | 0.574 | 1.000 | DLCS | 0.251 | -0.077 | 0.255 | 0.580 | 1.000 |
| VIF | | 1.67 | 3.82 | 2.56 | 2.73 | | | 1.02 | 1.26 | 1.80 | 1.51 |
| Mean VIF | | | 2.69 | | | | | | 1.40 | | |

MODEL IV

| | LCO2PC | LFDIS | LE | LT | LCS | | DLCO2 | DLFDIS | DLE | DLT | DLCS |
|---|---|---|---|---|---|---|---|---|---|---|---|
| LCO2PC | 1.000 | | | | | DLCO2 | 1.0000 | | | | |
| LFDIS | 0.328 | 1.000 | | | | DLFDIS | -0.053 | 1.000 | | | |
| LE | 0.856 | 0.468 | 1.000 | | | DLE | 0.890 | -0.107 | 1.000 | | |
| LT | 0.440 | 0.693 | 0.719 | 1.000 | | DLT | 0.506 | -0.170 | 0.456 | 1.000 | |
| LCS | 0.545 | 0.375 | 0.793 | 0.574 | 1.000 | DLCS | 0.251 | -0.004 | 0.255 | 0.580 | 1.000 |
| VIF | | 1.93 | 3.75 | 3.12 | 2.70 | | | 1.05 | 1.26 | 1.84 | 1.53 |
| Mean VIF | | | 2.87 | | | | | | 1.42 | | |

To see the order of the integration of the variables were executed the 2nd generation unit root test, namely the *cross-sectionally augmented IPS* (CIPS) test by Pesaran, 2007. The test was only used because the presence of cross-sectional dependence was registered in all variables and the 1st generation panel unit root tests turn to be inefficient in these cases. According to Table 4., the results show that some variables are I(1) and other are I(0), which is not a problem, because the ARDL model support these two levels of the integration. This confirms that the ARDL methodology is the best approach for this study and the results of CIPS test show that none of the variables are I(2).

TABLE 4: PANEL UNIT ROOT TEST (CIPS)

| | CIPS (Zt-bar) | |
|---|---|---|
| | without trend | With trend |
| LCO2 | -1.855** | -0.087 |
| LFDI | -1.716** | -0.768 |
| LFDIM | -1.446* | -0.371 |
| LFDIMAN | -1.045 | -1.308* |
| LFDIS | -3.422*** | -3.104*** |
| LE | -0.504 | 1.428 |
| LT | 2.423 | 1.786 |
| LCS | -1.210 | 0.862 |
| DLCO2 | -3.817*** | -2.471*** |
| DLFDI | -2.287** | -1.360* |
| DLFDIM | -2.464*** | -0.613 |
| DLFDIMAN | -1.794** | 1.274 |
| DLFDIS | -3.755*** | -2.295** |
| DLE | -1.339* | 0.750 |
| DLT | 0.011 | 2.509 |
| DLCS | -0.072 | 1.638 |

Notes: ***,**, * denote statistical significance at 1%, 5%, 10% level, respectively; Pesaran (2007) Panel Unit Root Test (CIPS) assumes that cross-sectional dependence is in form of a single unobserved common factor and H0: series is I(1); To compute this test, the Stata command *multipurt* was used.

After observing the order of integration of the variables, in the panel approach is necessary to verify the presence of random effects or fixed. The Hausman test confronts fixed effects (FE) and random effects (RE). The null hypothesis of the Hausman test is “the difference in coefficients is not systematic”. Table 5., portrays the results of the test for all models and show that the null hypothesis was rejected. This led to the conclusion that the fixed effects model is the proper specification to the estimations, that is, the countries individual effects are significant.

TABLE 5: HAUSMAN TEST

| | MODEL I | MODEL II | MODEL III | MODEL IV |
|---|---|---|---|---|
| Hausman test | FE vs. RE | FE vs. RE | FE vs. RE | FE vs. RE |
| | Chi2(9) = 28.85*** | Chi2(9) = 28.31*** | Chi2(9) = 22.17*** | Chi2(9) = 25.75*** |

Notes: *** denote significance at 1% level. H0: difference in coefficients is not systematic. The Hausman test for model II and model III was performed with the *sigmamore* option and for model IV was formed with the *sigmaless* option.

## 4. Results and discussion

After the Hausman test, it is necessary to execute some specification tests. To teste the presence of heteroscedasticity was computed the Modified Wald Test, which the null hypothesis is homoscedasticity. Pesaran's test is that residuals are not correlated and follow a normal distribution. Lastly, was used the Wooldridge test for autocorrelation to test for the presence of serial correlation in our model with the null hypothesis of no serial correlation.

The results of previously explained tests are presented in Table 6., and show that heteroscedasticity and first-order autocorrelation are present in the model.

TABLE 6: SPECIFICATION TESTS FOR MODEL I

| | Statistics |
|---|---|
| Modified Wald test | 671.53*** |
| Pesaran's test | -1.130 |
| Wooldridge test | 13.990*** |

Notes: H0 of Modified Wald test: sigma(i)^2= sigma^2 for all I; H0 of Pesaran's test: residual are not correlated; H0 of Wooldridge test: no first-order autocorrelation; *** denote statistical significance at 1% level.

After checking the results, the Driscoll and Kraay, (1998) estimator is the most appropriate one to use, because it generates robust standard errors that allows to obtain robust results due to the presence of cross-section dependence, heteroscedasticity and autocorrelation.

Every country shows political, economic and social problems sometimes and therefore, once these problems have an impact on the country's economy, was considered the relevant shocks which affected their economies between 2005 and 2016, in this case, the relevant shocks that affect the CO2 emissions in these countries.

The Kyoto Protocol is an agreement of the United Nations Framework Convention on Climate Change (UNFCCC), which sets emissions reduction

targets. The first commitment started in 2008 and ended in 2012, which explain the break in CO2 emissions in 2012 to Austria and Latvia. (UNFCCC, 2018)

On March 11 of 2011 occurred the disaster of the nuclear central of Fukushima, which did the Japanese manufacturer's greenhouse gas emissions rises, affecting the country's carbon reduction goals under the Kyoto Protocol, because they started to use own electricity generators to guarantee energy.

TABLE 7: ESTIMATION RESULTS

| Dependent Variable: DLCO2 | FE | FE-DK |
|---|---|---|
| Constant | -0.5309 | -0.5309 |
| TREND | -0.0037*** | -0.0037*** |
| DLFDI | 0.0134 | 0.0134 |
| DLE | 0.9806*** | 0.9806*** |
| DLT | 0.1055*** | 0.1055*** |
| DLCS | -0.0369* | -0.0369* |
| LCO2 (-1) (ECM) | -0.2789*** | -0.2789*** |
| LFDI (-1) | 0.0109 | 0.0109* |
| LE (-1) | 0.2759*** | 0.2759*** |
| LT (-1) | 0.0608** | 0.0608** |
| LCS (-1) | -0.0092 | -0.0092 |
| AUS2012 | -0.0699*** | -0.0699*** |
| JAP2012 | 0.0850*** | 0.0850*** |
| LAT2012 | -0.0728*** | -0.0728*** |
| DIAGNOSTIC STATISTICS | | |
| N | 165 | 165 |
| $R^2$ | 0.8640 | 0.8640 |
| F | F(13,137)= 66.93*** | F( 13,10)= 4227.29*** |

Notes: ***, **, * denote statistical significance at 1%, 5%, 10% level, respectively; To estimate the models the Stata command *xtscc* was used.

What was said previously points to the existence of outliers in Austria (2012), Japan (2012) and Latvia (2012). To control the detected outliers were added dummies on the model to represent these events and correct them. The dummies AUS2012 and LAT2012 represents a break, and JAP2012 represents a peak.

The long-run elasticities are not present in Table 7., because those elasticities had to be calculated through the ratio between the variable's coefficient and the LCO2 coefficient, both lagged once, and multiply this ratio by -1. Table 8., shows the semi-elasticities (short-run), elasticities (long-run), and the adjustment speed of the model (ECM – error correction mechanism).

TABLE 8: ELASTICITIES AND SPEED OF ADJUSTMENT

| Dependent Variable: DLCO2 | FE | FE-DK |
|---|---|---|
| Short-run semi-elasticities | | |
| DLFDI | 0.0134 | 0.0134 |
| DLE | 0.9806*** | 0.9806*** |
| DLT | 0.1055*** | 0.1055*** |
| DLCS | -0.0369* | -0.0369* |
| Long-run (computed) elasticities | | |
| LFDI (-1) | 0.0391229 | 0.0391229** |
| LE (-1) | 0.9891418*** | 0.9891418*** |
| LT (-1) | 0.2181112** | 0.2181112*** |
| LCS (-1) | -0.0328407 | -0.0328407 |
| Speed of adjustment | | |
| ECM | -0.2789*** | -0.2789*** |

Notes: ***, **, * denote statistical significance at 1%, 5%, 10% level, respectively, the ECM denotes the coefficient of the variable LCO2 lagged once.

From the Table 8., it is possible to see that CO2 emissions of the OECD countries was positively affected by the energy consumption, both in the short-run and the long-run, which means that an increase on the energy consumption increases the CO2 emissions, likewise that was previously stated from Sapkota and Bastola, (2017). Trade openness show to increases CO2 emissions, both in the short-run and long-run, which goes like what Sbia et al., (2014) found. Analyzing the FDI coefficient it is possible to conclude that FDI increases the CO2 emissions just in the long-run and shows no significance in the short-run. The reason to FDI shows no significance in short-run could be because the environmental consequences of the FDI are considered to be a long-run phenomenon (Baek, 2015). In the long-run, inward FDI increases CO2 emissions which supports the PHH.

The capital stock is significant in the short-run and reveals that an increase on the capital stock decreases the CO2 emissions. This finding goes against what Sapkota and Bastola, (2017) found. Nevertheless, if capital stock decreases the CO2 emissions and is related with capital-intensive industries which generally consumes more energy and could lead to increase pollution, this effect could be because of the energy savings, the adoption of green technologies and maybe because of high level of human capital of the countries on analyzing.

Regarding the ECM, from Table 8., it is possible to see that the coefficient is negative and significant which indicates the presence of long-memory between the variables. This value represents the speed of adjustment of the model, this is, the speed at which the dependent variable returns to equilibrium after changes in the independent variables. The speed of adjustment of the model is relatively fast.

## 5. Sectoral FDI: Results and discussion

To increase the model robustness, was decided to disaggregate the FDI into sectors following Doytch and Uctum, (2016**)** and Doytch and Narayan, (2016), to analyze de impact of the mining FDI, manufacturing FDI and total services FDI in the CO2 emissions.

Due to the high correlation between aggregate FDI, and the disaggregates FDI, will be doing additional three models. Every test that was done to Model I, was made to all models.

The Table 5., (see section 3), shows the Hausman test and it is possible to conclude that all models have fixed effects. Table 11., presents the specification tests previously specified (see section 3). Heteroscedasticity and first-order autocorrelation are present in all models.

TABLE 11: SPECIFICATION TESTS

| | MODEL II | MODEL III | MODEL IV |
|---|---|---|---|
| | Statistics | Statistics | Statistics |
| Modified Wald test | 550.56*** | 1419.87*** | 1166.74*** |
| Pesaran's test | -1.422 | -1.423 | -1.153 |
| Wooldridge test | 15.579*** | 14.334*** | 13.739*** |

Notes: H0 of Modified Wald test: sigma(i)^2= sigma^2 for all I; H0 of Pesaran's test: residual are not correlated; H0 of Wooldridge test: no first-order autocorrelation; *** denote statistical significance at 1% level, respectively.

Thus, the Driscoll and Kraay (1998) estimator is also the most suitable estimator to use in the estimations.

Table 12., presents the estimations results from the models of the sectoral FDI: Model II present the mining FDI, Model II the manufacturing FDI and Model IV the services FDI. The model is already corrected for shocks, because in the Model I the correction presented more robust results.

If we check the $R^2$ of the models, for example in the Model II, corresponds to 86.47% (0.8647), which indicates that about 87% of the variation in the pollution emissions (namely co2 emissions) is explained by the explanatory variables in the model.

Like was stated previously in Section 4 about the problems in these countries, shocks were also corrected in these three disaggregated models.

The shock in Turkey only appear in the Model IV. Turkey has not included in the Kyoto Protocol because they already used renewable energy and being progressed in the energy sector reform since 2001, however the financial support of fossil fuels has been rising, because they wanted to reduce foreign fuel dependence. Turkey has the G20's 6$^{th}$ largest share of coal in the energy supply and in 2014 represents 31% of the total energy consumption. (Climate-transparency, 2017)

TABLE 12: ESTIMATION RESULTS

| Dependent Variable: DLCO2 | Model II | Model III | Model IV |
|---|---|---|---|
| Constant | -0.5258 | -0.7803* | -0.6540 |
| TREND | -0.0038*** | -0.0035*** | -0.0032*** |
| DLFDIM | 0.0016 | | |
| DLFDIMAN | | 0.0015 | |
| DLFDIS | | | 0.0111** |
| DLE | 0.9850*** | 0.9868*** | 0.9823*** |
| DLT | 0.0986*** | 0.1017*** | 0.1095*** |
| DLCS | -0.0301 | -0.0324* | -0.0357* |
| LCO2 (-1) (ECM) | -0.2973*** | -0.2545*** | -0.2557*** |
| LFDIM (-1) | 0.0029** | | |
| LFDIMAN (-1) | | -0.0024 | |
| LFDIS (-1) | | | 0.0012 |
| LE (-1) | 0.2989*** | 0.2443*** | 0.2477*** |
| LT (-1) | 0.0615*** | 0.0655*** | 0.0591** |
| LCS (-1) | -0.0048 | -0.0092 | -0.0074 |
| AUS2012 | -0.0690*** | -0.0723*** | -0.0705*** |
| JAP2012 | 0.0809*** | 0.0867*** | 0.0875*** |
| LAT2012 | -0.0721*** | -0.0724*** | -0.0719*** |
| TUR2014 | | 0.0676*** | 0.0652*** |
| Diagnostic statistics | | | |
| N | 165 | 165 | 165 |
| $R^2$ | 0.8647 | 0.8735 | 0.8765 |
| F | F(13,10)= 2980.86*** | F( 14,10)= 3268.34*** | F( 14,10)= 4026.03*** |

Notes: ***, **, * denotes statistical significance at 1%, 5%, 10% level, respectively; To estimate the models the Stata command *xtscc* was used.

Observing all models simultaneously, it is important to note that the difference in the explanatory variables and their statistical significance is not very much. The significance between control variables is quite equal through the models. In the case of the interest variables it is different and differ into the short-run and the long-run.

TABLE 13: ELASTICITIES AND SPEED OF ADJUSTMENT

| Dependent Variable: DLCO2 | MODEL II | MODEL III | MODEL IV |
|---|---|---|---|
| Short-run semi-elasticities | | | |
| DLFDIM | 0.0016 | | |
| DLFDIMAN | | 0.0015 | |
| DLFDIS | | | 0.0111** |
| DLE | 0.9850*** | 0.9868*** | 0.9823*** |
| DLT | 0.0986*** | 0.1017*** | 0.1095*** |
| DLCS | -0.0301 | -0.0324* | -0.0357* |
| Long-run (computed) elasticities | | | |
| LFDIM (-1) | 0.0097502*** | | |
| LFDIMAN (-1) | | -0.0095602 | |
| LFDIS (-1) | | | 0.0046048 |
| LE (-1) | 1.005487*** | 0.9598599*** | 0.9686*** |
| LT (-1) | 0.2069583*** | 0.2573815*** | 0.2309194*** |
| LCS (-1) | -0.0162529 | -0.0362309 | -0.0289616 |
| Speed of adjustment | | | |
| ECM | -0.2973*** | -0.2545*** | -0.2557*** |

Notes: ***, **, * denotes statistical significance at 1%, 5%, 10% level, respectively, the ECM denotes the coefficient of the variable LCO2 lagged once.

In Model II, the interest variable is significant in the long-run and shows no significance in the short-run, like what happened in the Model I. The energy consumption and trade openness are strongly significant and positive, both in the short-run and long-run, which means that when they increase, the CO2 emissions increase like as previously stated. The mining FDI increases, in the long-run, the CO2 emissions which support the PHH.

In Model III, the manufacturing FDI shows no statistically significant impact in the CO2 emissions. The control variables present the same significance, and capital stocks show significance only at 10% level in the short-run.

In Model IV, the services FDI shows statistical significance in the short-run and that an increase in the services FDI increases the CO2 emissions which also support the PHH. The incorporation of advanced techniques could not be enough to correct the impacts of the FDI in the CO2 emissions in the short-run. (Shahbaz et al., 2019)

Energy consumption and trade openness, both in the short and the long-run, show to be statistically significant in the CO2 emissions what supports the findings of Sapkota and Bastola, (2017) and Sbia et al., (2014), respectively.

The significance of the capital stock differs from model to model, but in all models shows a negative impact in the CO2 emissions what goes against what Sapkota and Bastola, (2017) found. This could happen because of the industries different technology levels and because of the different level of investment in the human capital from sector to sector.

The mining and services FDI shows statistically significance, either in the short-run or in the long-run, but both had a positive impact in the CO2 emissions, this is, an increase in the mining FDI or in the services FDI results in an increase in the CO2 emissions in the OECD countries, which supports the Pollution Haven Hypothesis (see Section 2). Manufacturing FDI shows no significance in the

model, like Doytch and Uctum (2016) that do not achieve any significance in manufacturing FDI to middle-high income countries.

Regarding the central question of this study (see Section 1), the inward aggregate FDI seems to have a positive impact on CO2 emissions, which means that an increase in the FDI increases the CO2 emissions on the OECD countries, which supports the PHH. (see Section 2). The same conclusion to mining FDI and services FDI. The manufacturing FDI shows to be not significant in the CO2 emissions in these countries.

The policy-makers must stringent the environmental laws (directly involved with foreign direct investment in the host countries) and regulate the clean FDI.

## 6. Conclusions

The main goal of this investigation was to understand if the FDI has an impact on the CO2 emissions in the 15 OECD countries dividing this central question into three sub-questions disaggregating FDI into mining FDI, manufacturing FDI and services FDI (see section 1). The specifications tests showed that cross-sectional dependence, heteroscedasticity and first order-autocorrelation were present in the model, thus the Driscoll-Kraay estimator was used with fixed effects.

From the results in the Model I, the results show that FDI increases the CO2 emissions in the OECD countries, which supports the Pollution Haven Hypothesis (see section 2). It is important to note that the capital stock, shows a weak significance in the model in the short-run with a negative impact in the CO2 emissions, this is, an increase in the capital stock decreases the CO2 emissions, and this could be because of the energy savings, the adoption of greener technologies and the investment in human capital.

The results from Model II and IV are similar. The interest variables show to increase the CO2 emissions which also supports the Pollution Haven Hypothesis.

The manufacturing is a dirty industry, so, even that the manufacturing FDI shows no significance in the model, in the long-run, it could help in reducing emissions, what means that an increase in the manufacturing investment could turn significant to the CO2 emissions and benefits the countries. Hence, the manufacturing FDI inflows must be regulated just to entry clean FDI.

Concluding, the results from the capital stock shows that the countries should invest more in human capital, adopt more green technology and that could be happen through the clean FDI, therefore the policy makers should restrict the environmental laws, especially the ones related with the FDI, regulate the clean FDI and attract more clean FDI as possible.

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# 7 Energy Economics

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## 7.1 G1. Can ecological forms of governance avoid global tragedies of the commons? - Shann Turnbull

**CAN ECOLOGICAL FORMS OF GOVERNANCE AVOID GLOBAL TRAGEDIES OF THE COMMONS?**

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**ABSTRACT**

The research question is: might the ecological form of governance identified by Ostrom (2010) provide a way to avoid global tragedies of commons as it did for local commons in pre-modern societies? Modern organizations that meet the Ostrom description of being "polycentric compound republics" provide evidence that no changes in the law may be required to introduce this form of governance in major jurisdictions. Ecological governance represents "a new model of corporate governance" sought by Blackrock to meet its objectives. Blackrock is the largest investment fund manager in the world stated: "Companies must benefit all of their stakeholders, including shareholders, employees, customers, and the communities in which they operate" (Fink 2018). This would make such organizations a common good and so agents for promoting the common good globally whether or not they are publicly traded or are in the private, non-profit or government sectors. Ecological governance introduces distributed: (a) decision making; (b) cross-checking communication channels and (c) comprehensively diverse control centers competing for dominance according to internal and/or external existential risks and opportunities as demonstrated in the human brain. The science of governance, used to design self-governing automobiles, is introduced to explain why nature uses network governance rather than hierarchies to manage novel dynamic complexity. The operating advantages of ecological governance are identified and how elements could be introduced with or without government incentives. The OECD metrics for measuring the wellbeing of individuals and organizations are suggested as a way to evaluate and compare ecological and hierarchical forms of governance.

**Key Words:**

Ecological governance**,** Global commons, , OECD metrics, Stakeholder governance ,Wellbeing.

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**Introduction**

The research question is: might the ecological form of governance identified by Ostrom (2010) provide a way to avoid global tragedies of commons as it did for local commons in pre-modern societies?

Ostrom (1990) identified how in pre-modern societies, and in some contemporary traditional agricultural communities, complex inclusive stakeholder network relationships have been established so that the short-term interests of some individuals or groups to over exploit common resources are constrained to avoid destroying them for every one. A problem Hardin (1968) discussed as "The tragedy of the commons". Avoiding the tragedy of the commons is dependent upon establishing sustainable self-governance of the commons between competing individuals or groups.

***Inter-disciplinary relationships***. Self-governing systems like automobiles and space probes that can operate in dynamic novel complex environments are designed according to the physical laws of nature. The application of natural laws to social organisations has been made possible by my PhD dissertation (Turnbull 2000b). It introduced bytes of data as its unit of analysis to allow Transaction Cost Economics to become subsumed into Transaction Byte Analysis (TBA). No social relationship can arise within or between any specie without the transaction of bytes within and/or between creatures. No change in information, knowledge or wisdom can occur without bytes being transacted. No bytes can be transacted without perturbations arising in energy and/or materials that becomes subject to physical constraints and measurement.

The competing individuals or groups exploiting common resources would represent what Simon (1962) described as: "stable intermediate forms" (p. 470) or "relatively independent

sub-systems, each of which can be designed with only minimal concern for its interaction with the others" (p.474). This indicates how in nature, complex systems are made up of almost self-governing subsystems but with each sub-system having some minimal interdependence.

As political scientists, Elinor and her husband Vincent Ostrom referred to the "sub-systems" as "republics". Koestler (1967) coined the word "holon" to describe the subsystems described by Simon. Many other terms are also used as documented by Mathews (1996: 36-7) in his comprehensive description of holons and hierarchies of holons described as "holarchies". Hock, the founding CEO of the VISA card company coined the word " Chaord" by combining the contrary words "Chaos" and "Order". Hock (1999) defines a Chaord as:

> Any self-organizing, self-governing, adaptive, nonlinear, complex organism, organization, community or system, whether physical, biological or social, the behavior of which harmoniously blends characteristics of both chaos and order.

The Ostroms variously described the form of network governance they identified as "polycentric republics" or "compound republics". My PhD dissertation established a methodology to analyse such networks and defined a "compound board" as arising when an organisation was governed by two or more boards or "control centres" (Turnbull 2000b: 4). The stakeholder controlled nested networks of networked governed firms of the Mondragón Corporacion Cooperativa (MCC) based in Spain have created polycentric compound republics.

***Operating advantages.*** Introducing ways to avoid the tragedy of the commons is perhaps the most important contribution that can be made by introducing inclusive organizations. This is because they provide a way to mitigate damage to the global commons from problems like pollution and climate change. The solution is not dependent upon establishing a single world government. Nor is the solution dependent on "Markets and Hierarchies" as considered by

Williamson (1975). Instead it depends on federating ecological networks of almost self-governing republics in one form or another as proposed in a study by Ostrom (2010) for the World Bank.

Besides avoiding a tragedy of the commons, inclusive organisations can also improve business efficiency and resiliency. The MCC is a notable example that has grown organically from a single firm in 1956 to around 200 firms today with superior efficiency compared with investor owned firms as reported by Thomas & Logan (1982: 126-127).

The New York publicly traded company BlackRock is promoting inclusive organizations with stakeholder involvement globally as the largest investor in the world managing $6.4 trillion. Fink (2018), as a co-founder, chair and CEO of BlackRock, wrote to all his investee companies to inform them that: “Companies must benefit all of their stakeholders, including shareholders, employees, customers, and the communities in which they operate”. He went on to identify the need for firms to involve stakeholders in their governance processes as raised by Roberson (2018) and so what he described as: “A new model of corporate governance”.

The ability of this article to outline the details of how to achieve the outcomes described by both Ostrom and Fink are based on my experience educating company directors about Mondragon (Turnbull 1975b) and as a serial entrepreneur in the 1980’s putting into practice governance innovations for both for profit firms (Turnbull 2002d) and national non-profit associations. I was able to also directly share the insights of the Ostroms though undertaking the first economic analysis of the oldest existing pre-modern society (Turnbull 1980). These experiences motivated my PhD research that revealed how command and control hierarchies are inconsistent with the laws of nature as also describe by Hock (1995) explained below.

The new way to govern required by Fink can be created from adapting the ancient ones described by Ostrom. I describe this as “ecological” governance because it is universally found in natural systems. It allows complexity to be reliably and comprehensively simplified

as much as required. The human brain and the compound boards of the MCC illustrate the data communication and control architecture of ecological governance (Turnbull 2000b: 245). Data processing is distributed to reduce data overload for neurons in a brain of and/or individuals in an organization. Simple centrally controlled command hierarchies can only simplify complexity incompletely. This introduces unreliability while at the same time not avoiding data overload. Compare this situation with our brains.

The brain has no Chief Executive Neuron (Kurzweil 1999: 80). Different parts of the brain compete for decision-making dominance according to human internal existential needs and external risks and opportunities (Kelso 1995, Kelso, Dumas & Tognoli 2013, NINDS 2018). Ecological governance explains how millions of very small-brained ants can make complex decisions from the bottom up about when, where and how to design, build, operate and maintain their complex homes (Attenborough 2018).

***Academic contributions***. Two other contributions of this paper is that it pioneers research into: (a) comparing the efficacy of simple central command and controlled hierarchies on which theories of the firm were developed by Coase (1937) and extended by Williamson (1985), with ecologically governed network organizations with distributed decision-making; and (b) how these two different types of governance architectures affect the wellbeing of either individuals or organizations. Neither Coase nor Williamson possessed the intellectual tools to analyze organizations with distributed decision-making whose importance Ostrom documented because, as noted by Radner (1992: 1384), there was no way to analyze "hierarchical and non-hierarchical organizations within a common model". William (1985: 265) recognized the existence of Mondragón and admitted that: "further study is needed". This made it appropriate for the 2009 Nobel Prize being shared by Ostrom and Williamson.

Evidence that the above two contributions are pioneering research is provided by the Social Science Research Network (SSRN) archives. Of the 837,965 papers archived as at 1 January

2019, 15,973 papers were about corporate governance. Only eight of these papers were concerned with both "corporate governance" and "wellbeing". Only two of the eight papers considered different types of governance with the wellbeing of individuals and the organisation. One of these two was my own with the other being by Ribstein. Ribstein (2009) considered "partnership governance of large firms"; firm performance, and limited "economic wellbeing" to only the senior managers – not other stakeholders.

The OECD (2017: 188) recognises that "a conceptual framework for governance statistics is still lacking. No universal definition for governance presently exists". This paper could provide a framework for using ecological forms of governance as reference standard for evaluating sound governance that supports the wellbeing of individuals and organisations. The OCED (2017: 174) did recognise that "Stakeholder engagement is also an important channel for implementing forms of participatory democracy" as mentioned in the following sub-section.

***Practical contributions***. Other contributions of this paper are to outline how: (a) to design a new model of corporate governance based on establishing subsystems that can be described as polycentric compound republics; (b) corporations, and organizations in general, can become the common good that can then in turn promote global common goods and the wellbeing of individuals, democracy and the environment.

The next section reviews some relevant theoretical concepts. The third Section considers the wellbeing of organizations governed by simple hierarchies. The OECD metrics for individual wellbeing are introduced in the fourth section to consider how wellbeing may change with hierarchies or ecological networks. The fifth section considers macro economic outcomes with the concluding section identifying research limits, agenda's and conclusions.

**Review of Some Relevant Concepts**

This Section introduces some special words used to describe some special concepts like Holons, Holarchy and Tensegrity. Smuts (1926) initially identified how the complexity of nature was created from simpler sub-components. Koestler (1967) coined the term "Holon" to describe the components identified by Smuts and Simon and their polycentric nested structure as a "Holarchy". Koestler coined the word Holon by combining the Greek words for "Whole" and "Part" to recognize the dual nature of holons that possess contrary/complementary interconnected Yin~Yang like characteristics. Quantum physicist Bohm (1980) proposed these characteristics are fundamental in the architecture of the universe. Holonic organizations are fundamentally different from hierarchies as indicated above by the definition of Chaords by Hock (1999).

Like quantum particles holonic organisations can exhibit, at the same time, contrary~complementay features like being: centralised~decentralised, bottom-up~top-down, automonous~integrated, order~ambiguity (Mathews 1996: 52-53). These properties are antithetical to command and control hierarchies that dominant modern society. Modern humans are the only social creatures that use simple hierarchies to govern the collective activities of a large number of individuals. Hierarchical organizations depend upon reliable obedience, subservience, conformity and group think. Alternative views may be encouraged to some extent but typically they can be career threatening. Yet all social creatures have contrary~complementary behavior hard wired into them like: flight~fight, cooperativeness~competitiveness; love~hate, altruism~selfishness (Kelso & Engstrøm 2006).

***Tensegrity***. Fuller (1961) coined the word "Tensegrity" from combing the words "tensional integrity" to explain the structural integrity that arises from combing material with contrary characteristics. The tension~compression interactions of tensegrity minimize materials, adds structural resiliency, and provides the most efficient possible use of space. Tensegrity allows geodesic domes to cover the greatest area with the least material. This suggests that tensegrity

provides social biota the maximum ability to survive novel dynamic complex environments while minimising the transaction of bytes, brain size and energy consumption (Turnbull 2000b: 134).

Tensegrity explains why nature uses materials with contrary properties to build living things. Biologist Ingber (1998) describes tensegrity as "The architecture of life". For example, it would be difficult to construct a stable structure from either a bag of all the bones in a human, that are best used in compression or a bag of all the muscles in a human, that are best used in tension. But by combining both these materials that possess contrary properties new characteristics emerge to create a huge variety of stable structures. Tensegrity resonates with the Chinese philosophy of Yin and Yang that "describe how seemingly opposite or contrary forces may actually be complementary, interconnected, and interdependent, in the natural world, and how they may give rise to each other as they interrelate to one another" (Wikipedia 2017).

The need for systemic fractions with contrary views as a way to counter tyranny has been recognized by political scientists (Buchan & Tullock 1962; Hamilton, Madison & Jay, 1787; Hayek, 1944; Ostrom & Allen, 2008; Ostrom & Ostrom 1971; Popper 1945).

The relevance of tensegrity for social institutions is that it also explains why DNA hard-wires contrary behaviour into biota as noted by Kelso and Engstrøm (2006). They introduced the tilde notation of "~" to indicate a contrary~complementary relationship. Survival of social animals not only depends upon contrary behaviour like approach~avoidance but on other contrary behaviours like being cooperative~competitive, trusting~suspicious, altruistic~selfish and so on (Kelso 1995; Kelso, et. al 2013). Hard-wired contrary behaviour allows fauna to generate a huge repertoire of responses to learn how to survive and thrive in novel unknowable dynamic complex environments. This feature is missing in hierarchies to reduce their resilience to survive and thrive.

Like geodesic domes tensegrity allows fauna to obtain a "requisite variety" of communication and control responses using the least amount of data processing materials and/or energy (Ashby 1956: 211).

***Hierarchies jeopardize or deny integrity***. Hierarchies deny tensegrity to achieve reliable advantages or even existence. This is because hierarchies incompletely simplify complexity by filtering out data, information, knowledge and wisdom through each of its levels. This introduces omissions, biases, distortions, ambiguities and deniable misunderstandings (Downs 1967). Evidence of these problems has been provided in reports on systemic business failures (RC 2018; DoJ 2012a,b; Faulkner 2018; Peltz 2018).

***Human limits in data processing***. Humans illustrate the crucial evolutionary importance for fauna to minimise their data processing materials and energy for governing their survival. "In the average adult human, the brain represents about 2% of the body weight. Remarkably, despite its relatively small size, the brain accounts for about 20% of the oxygen and, hence, calories consumed by the body" (Raichle & Gusnard 2002). As noted by Ashby (1956: 270) "The gene-pattern, as a store of channel variety has limited capacity. Survival goes especially to those species that use the capacity efficiently". Tensegrity allows DNA to efficiently transmit a requisite variety of complexity for survival and replication in novel environments. While computers now exceed human abilities in data processing they have not yet matched the compactness, energy efficiency and mobility of human neurological data processing.

Even though humans are distinguished by their large brains, small simple minded insects like ants and bees are still capable of collective decision making about when, where and how to design, build, operate and maintain their complex dwellings. As reported by Mathews (1996: 30) in describing how robots are designed. "The reduction in data transmission, and in data complexity, achieved by holonic architecture, is prodigious. Moreover, the advantages accumulate as the robotic devices get more complex."

All social fauna, except modern humans survive and thrive in novel complex dynamic environments, by adopting ecological forms of governance. This is because networks distribute decision making to simplify complexity as comprehensively as required while hierarchies simplify complexity incompletely by filtering data that can obscure harms, opportunities and existential threats.

In referring to human limitations, Williamson (1975: 21) observed: "the physical limits take the form of rate and storage limits on the powers of individuals to receive, store, retrieve and process information without error." Williamson (1975: 45–46) noted that: "a change in organizational structure may be indicated" when individuals are exposed to "information-processing limits".

Some change in organizational architecture was achieved by the development of Multi-divisional or M-form firms in the early 20th century. Williamson (1985: 283) saw M-form firms as a way "of decomposing the entire enterprise in efficient informational processing aspects". However, as complexity increased this form of decomposition introduced the problem of divisional silos becoming disconnected (Turnbull and Pirson 2012). Each silo was still constituted as a command and control hierarchy with insufficient cross connections. Ecological networks mitigate this problem by providing "prodigious" reduction in data processing noted above by Mathews (1996: 30).

In the following section the systemic problems inherent in hierarchical institutions to achieve operating wellbeing are considered.

**Impact of Hierarchies on Organizational Wellbeing**

As noted above one fundamental problem of hierarchical organizations is that in each level of their command chain, subordinates must filter the data reported to avoid their superiors being subject to data overload. In the context of hierarchical organizations this questions the ability

of executives to reliably exercise the requirement raised by Arrow (1974: 68-70) that: "Authority is needed to achieve a coordination of the activities of the members of the organization".

Coase (1937) had already refuted the practicality of the Arrow requirement when he answered his own question: "Why is not all production carried on by one big firm?" A more compelling reason to explain why authority cannot be reliably exercised in centralized command and control hierarchies is provided by "the science of control and communications in the animal and machine" described as "cybernetics" (Wiener 1948). The laws of cybernetics "absolutely prohibits any direct and simply magnification" of reliable authority through a large organization (Ashby 1956: 268). Magnification of control is only possible indirectly by independent supplementary co-regulators that then form components of a network organization. Some political scientists, led by the Ostrom's, have recognized the relevance of Ashby's Law of requisite variety to govern complexity (Ostrom & Ostrom 1971; Ostrom, Feeny & Picht, 1993: 66; Ostrom 1998: 150; Ostrom & Allen 2008: 253).

Humans have both physiological and neurological limits in processing bytes. Cochrane (2000), as head of the British Telecom research laboratories, first made public the physiological limits for human to receive bytes by sight, sound, touch, taste and smell. MIT speech recognition scientist Kurzweil (1999:103) identified the limited ability of the human brain to process and store data.

Beside the physiological and neurological limits there are limits of language. According to Williamson (1975:21): "Bounded rationality involves neurophysiological limits on the one hand and language limits on the other". Many people have played the party game of "telephone" where teams of four or so people compete with another team to transmit the same message. Even with the most careful cooperative efforts the message often becomes subject to errors (Downs 1967: 116-118). In a business hierarchy, the problem is compounded by the

incentive of subordinates to bias, obscure and/or omit any data that might be seen to reflect on their performance and so put at risk their pay, promotion or even employment.

However, it is possible to increase the accuracy of communications as much as desired by introducing a requisite variety of independent crosschecking channels. This is an aspect of "the law of requisite variety" identified by a Bell Telephone engineer Shannon (1949). In any event, even if there were no communication errors, simple hierarchies deny, by definition, sufficient independent channels to communicate the complexity of the disturbances that need regulating.

Ashby's Law of requisite variety of control states that "R's capacity as a regulator [R] cannot exceed R's capacity as a channel of communication" (Ashby 1956: 211). This explains why it becomes impossible for simple hierarchies to reliably control complexity. Even if there was a requisite variety of communications channels Ashby's law of requisite variety of control introduces another problem. It states: "only variety can destroy variety" (Ashby 1956: 211). Stated another way it means that the variety of responses from any Regulator cannot be less than the variety of the Disturbances. This is illustrated by contact sports where a team is disadvantaged by not having as many players as the opponents.

The lack of requisite variety in either control or communication channels in simple hierarchies makes hierarchies intrinsically unreliable in identifying and/or countering weaknesses, harms or existential risks to further their wellbeing, let alone their existence. This explains why the human brain has no "chief executive neuron". More generally it explains why evolution does not employ a hierarchical command and control architecture to allow creatures to become self-regulating and self-governing to survive and thrive at their birth in complex dynamic complex environments.

Humans have added another dimension of why hierarchies governed by a single decision-making authority can deny wellbeing in organizations. Lord Acton[1] explained this problem when he wrote: "Power tends to corrupt, and absolute power corrupts absolutely. Great men are almost always bad men, even when they exercise influence and not authority, still more when you superadd the tendency or the certainty of corruption by authority."

The well-known solution is to introduce a division of powers as is found in political constitutions. However, this is not typically found in Anglophone jurisdictions for corporations. The exception is when new firms enter into a funding agreement with a Venture Capitalist (VC). As a condition for providing funds at the riskiest stage of the life of a firm, the VC obtains an agreement with shareholders that they take over the power to govern from both them and the directors. This provides evidence that there is no commercial reason for corporate constitutions not to separate the powers to govern from the powers to manage. A model constitution included in the UK Company Act (1862) made provisions in this regard for audit committees to be composed of shareholders instead of directors.

The separation of powers removes a systemic unethical conflict of interest for both directors and the external auditors. As directors pay the external auditors they could be seen as to be bribing those who judge the integrity of their accounts. Auditors could be seen as accepting a bribe to provide agreeable judgements. The official acceptance and enforcement of this systemic unethical conflict can establish a poisonous culture so business people can no longer distinguish between what is right and what is wrong. A situation widely revealed by a Royal Commission into misconduct in financial institutions (RC 2018). It did not occur to a number of witnesses that taking money out of pension fund accounts for no reason was a theft and so a criminal act! An act that some institutions tried to cover up and/or report late, which is

[1]Letter written in 1887 to an ecclesiastic scholar in the context of not supporting papal infallibility, April, <https://en.wikipedia.org/wiki/John_Dalberg-Acton,_1st_Baron_Acton>.

another crime, and/or tried to invent a service they provided to justify paying themselves what they and their regulators euphemistically described as "a fee for no service".

It is significant that it is only modern humans that use centralized command and control hierarchies to manage complexity. Hock (1995: 4) recognised this when he identified the lack of wellbeing of hierarchies by stating:

> Industrial Age, hierarchical command and control pyramids of power, whether political, social, educational or commercial, were aberrations of the Industrial Age, antithetical to the human spirit, destructive of the biosphere and structurally contrary to the whole history and methods of biological evolution. They were not only archaic and increasingly irrelevant; there were a public menace.

The menace of hierarchies to the wellbeing of organisations and society was recognised by Hock (1999: 6) nine years before the global financial crisis of 2008. He stated:

> We are experiencing a global epidemic of institutional failure that knows no bounds. We must seriously question the concepts underlying the current structures of organization and whether they are suitable to the management of accelerating societal and environmental problems – and, even beyond that, we must seriously consider whether they are the primary source of those problems.

A forensic analysis of the failure of Lehman Bros Inc in 2008 identified another growing systemic lack of wellbeing of hierarchies (Turnbull & Pirson 2012; Pirson & Turnbull 2015). The failure of Lehman represented a specific example of a systemic problem in hierarchies. This is the lack of communications between management silos (Pirson & Turnbull 2011). The silos disconnect communications between individuals who together possess: (a) Information to act to remove problems; (b) Incentive to act; (c) Power to act, and (d) Capability to act. In

other words, capitalism based on hierarchies can become "disconnected" (Turnbull & Pirson 2012).

The introduction of "For Benefit" or "B" corporations does not address this fundamental problem. Nor do B corporations eliminate the absolute power of a single board to identify and manage their own conflicts of interest. This creates "Toxic governance" from the power of directors to corrupt absolutely them the business and society (Turnbull 2014d)

The cure is to introduce appropriate division of powers with stakeholder networks to provide independent outside in, and bottom up, feedback and control channels. In this way hierarchies could evolve towards an ecological form of governance with distributed intelligence, communications and control. Their evolution into ecological forms of network-governed firms would require changes in their corporate charters but not necessarily any changes in civil law. The existence of large ecological governed firms like Visa International Inc in the US, The John Lewis Partnership in the UK and the MCC in Spain demonstrate that no changes in the law is required in major jurisdictions.

The option for firms to evolve into ecological forms of governance architecture is likely to exist in some form in most jurisdictions. How this change could affect the wellbeing of individuals is next considered.

**Impact of Hierarchies on Individual Wellbeing**

This section introduces the OECD (2017) framework to consider how hierarchies affect individual wellbeing. The OECD initiative arose from a commission set up by the French government in 2008 for the "Measurement of Economic Performance and Social Progress". The Commission was chaired by Joseph Stiglitz with Amartya Sen as the economic adviser and French Economist Jean-Paul Fitoussi as the Co-ordinator. The recommendations made by

the Commission sought to address concerns that standard macroeconomic statistics like GDP failed to give a true account of people's current and future wellbeing.

Hierarchies introduce asymmetries of power, prestige and privileges. These can be source of discontent and become more important as income levels increase (Ono & Lee 2016: 36). Hierarchies also introduce dysfunctional subservience, blind obedience, alienation, conformity and "group think". "Group think" in publicly listed firms was considered counter productive by (Fink 2018). Conformity is dysfunctional because social creatures and their organisations require as noted above a dynamic rich menu of behavioural responses to survive and thrive in novel complex and ever changing environments.

Humans are hardwired by their DNA to generate a rich menu of ever changing behaviours to survive and thrive. However, these instincts become suppressed and inhibited in hierarchies that depend upon subservience, obedience and conformity. Non-conformity can jeopardize promotion and even employment. Hierarchies can become frustrating, alienating and dehumanising to deny wellbeing be they be in the public, private or non-profit sectors.

The OECD (2017: 23) framework for analyzing individual wellbeing has eleven measures as illustrated in their Figure 1.1, "The OECD framework for measuring individual wellbeing" reproduced below. The framework contains eight "Quality of Life" indicators and three "Material conditions".

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Insert Figure 1 about here
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***Quality of Life***. The lack of accountability within hierarchies allows exploitation of employees or stakeholders in government or other non-profit organisations alike. This could be in the form of excessive demands for employees to undertake unpaid work to jeopardise quality of life measures like "Work-life balance" or psychological stress to affect "Health status". Health status may also be jeopardised by sexual harassment arising from

asymmetries of power that can exist even in religious or educational hierarchies. Reports of exploitation and neglect in health and age care hierarchies are not uncommon. In any case, other quality of life concerns like “Personal security” and “Subjective wellbeing” can also become adversely affected without systemic checks and balances commonly absent in hierarchies.

The excessive power of large hierarchical firms and government departments can make them impervious to negative feedback in the delivery of the goods and/or services to clients, shareholders, members and/or other stakeholders. The insensitivity of call centres, even if they are not located in alien cultures, in a case in point. Direct citizen engagement in the governance of hierarchical organisations is generally not available, ignored or when it is available it is impotent.

An important exception and exemplar of the efficiency of establishing formal stakeholder feedback are the Citizen Utility Boards (CUBs) established by Ralph Nader in the US. CUBs were established to counter price regulators being captured by managers (Givens 1991). CUBs were formed by Nader organising an insert to be distributed with the monthly invoices sent to millions of customers of regulated utilities providing electricity, gas or water. The insert invited customers to donate $10 to establish a price “watchdog” to counter the arguments of management with the regulator for price increases. A small minority of stakeholders donated sufficient funds to obtain savings in excess of their donation while providing a “free ride” for over 95% of the other customers.

There are numerous other examples of minority stakeholders committing personal resources to further the material or quality of life of others. A case-in-point are the non-profit shareholder associations established in some countries to represent the interest of retail investors. The impotence of retail investors to protect and further their common interests is widespread example of how the power of hierarchical organisations frustrates or fails to

become accountable even to the stakeholders to which they are legally accountable. Indirect engagement with organisations through their governing shareholders, members, or political leaders can be frustrated by lack of individual accessibility and/or resources. As noted above disconnections can exist between individuals that collectively have the information, incentive, power and capability to act.

Providing feedback on concerns on environmental degradation provides particular challenges to individual wellbeing. This is because the sources of problems may be unknown, distant and multi-sourced. Even when there exists a dedicated regulator, they may not be able to act expeditiously or effectively. However, networks can be established to include organisations and/or individuals with environmental interests as explicated by Turnbull (2014c). The advantage of hierarchies for dictators is they can shut out the voice and concerns of stakeholders who may be adversely affected by their operations.

This is why by either commission or omission hierarchies can adversely affect individual wellbeing in all the dimensions of quality of life measures. Hierarchies do not have an incentive for inclusivity. Network organisations do have an incentive for inclusivity as the reason for their existence can be lost if they do not establish tensegrity to achieve a comprehensive requisite variety of opposing contestable interests. Individual existence and wellbeing is fundamentally depended upon anti social impulses in our brains being subjected to checks and balance. Hierarchies can deny or inhibit contestability.

***Material conditions of individual wellbein.*** Only two of the three OECD "Material Conditions" are likely to become directly affected by the nature of the governance architecture of organisations. The two conditions of "Income and wealth", and "jobs and earnings", are subject to direct determination by command and control hierarchies in the private, non-profit and government sectors.

A major hidden problem of corporations is how they generate inequality by their investors being overpaid in way that is not reported by accountants (Turnbull 2000c, 2017). Accountants do not measure the overpayment of investors, because accounting doctrines do not require a report on investor time horizons. Any cash received beyond the investor's time horizon becomes a "surplus profit" not required to bring forth the investment (Turnbull 2000c: 403; 2006: 451-455). Surplus profit should not be confused with "excessive profits" or "economic rent". Accountants report both concepts but not surplus profits. Economists may use their term "economic rent" to explain profits investors' require for making an investment. Surplus profit is a different but complementary concept. It is the profit surplus to the incentive for making the investment.

Economists assume that market forces will limit excessive or any "surplus" payments. Indeed, this is both a core justification and a reason for supporting a market economy. But even when market forces do limit prices and so income, at any one time, they may not limit the extent of how much income and wealth may be aggregated over time when ownership and control rights extend indefinitely. In the context of international direct foreign investment Penrose (1956: 235) stated that it requires "the acceptance of an unlimited, unknown and uncontrolled foreign liability". This liability can drain out local wealth indefinitely to reduce the wellbeing of local citizens.

All intellectual property rights are time-limited. They also exist in private-public "Build, Own Operate and Transfer" (BOOT) partnerships. They also prove that investors accept time limits. To create a more equal investment playing field all commercial property rights need to likewise become time limited without necessarily requiring any business operations to become time limited with the transfer of ownership.

Because surplus profits are not reported they cannot be taxed. However, the can still be widely distributed by companies changing their constitutions to create "stakeholder" shares

that are gifted/endowed to stakeholder citizens over time. Tax incentives can be used to promote the democratising the wealth of nations and the wellbeing of citizens in this way (Turnbull 1975, 2000c, 2014a). It would provide a way to meet the requirement of Fink (2018) that "Companies must benefit all of their stakeholders".

The capture and concentration of undisclosed, unnoticed surplus profits arising from firms, denies improving the material wellbeing of individual stakeholders and others in society. The opportunity to achieve this objective and at the same time introduce network governance is considered in the following section.

**Wellbeing and Ecological Stakeholder Governance**

This section considers how an ecological form of governance could be introduced on a voluntary basis to overcome the problem of hierarchical firms systemically overpaying investors to exacerbate inequality in a way not identified by policy advisers and economists like Piketty (2014). This process could also increase the wellbeing of individual stakeholders to create a virtual self-reinforcing way of increasing wellbeing for all individuals in society by contributing to Universal Basic Income (UBI).

Fiduciary shareholders like pension funds would have a legal obligation to give up ownership and control in return for higher returns. Paradoxically government tax revenues could increase as the tax base transfers from corporations to individuals who are typically taxed at a higher rate. A process is created for funding a UBI to underwrite the material wellbeing for citizens on a basis that also reduces tax, the size of government and welfare payments.

The formation of such ecological governance that endows stakeholders with ownership and control would keep firms to human scale and facilitate self-governance (Turnbull 2014a). Ownership time limits create an incentive for firms to distribute most, if not all profits each

year as dividends. This is because equity in any profits retained would be reduced each year by automatically being endowed to stakeholder shares. Continuity and business growth would be funded by dividend re-investment plans in "offspring" firms sponsored by progenitor firms, perhaps augmented with new investors. The offspring firms would be given birth by acquiring for cash some of the assets, activities, and related staff from their birthing firm. The success of this method of replication and growth is illustrated in nature by amoeba, and for organisations by the MCC.

The MCC has grown mainly through the spin-off of new firms from existing firms since the first cooperative was established sixty years ago (Turnbull 2000b: 273-293). This explains how the MCC has kept its component entities to human scale while also growing by giving birth to a network of networked governed firms. Member firms of the MCC did not issue shares that were publicly traded so time limits were not required to distribute surplus profits. Surplus profits were shared through stakeholder cooperative membership determined by self-management processes within the cooperative firms.

Corporations that issue publicly traded shares become ecological when they replace conventional exclusive, static and perpetual property rights with ones that are inclusive, dynamic and time limited. "All structures in animate nature are actually dynamic" (Kelso 1995: 5). Ecological ownership and control provides: (a) a way to recycle both business activities and investment in a process of "creative destruction" that, (b) limits systemic overpayments to investors, and (c) legitimises the introduction of stakeholder governance even with the existence of private property rights.

The legitimisation of stakeholder governance becomes compelling from the need to introduce a requisite variety to provide reliable self-regulation and self-governance. Social scientists have yet to apply the knowledge of self-regulation and self-governance that engineers use to design self-regulating and self-governing space probes and self-driving

automobiles. The introduction of stakeholders into the governance architecture of corporations would represent a first step. Including stakeholders into the governance architecture would allow the integration of Corporate Social Responsibilities (CSR) into the governance of organisations.

The operating and/or competitive advantage from introducing elements of stakeholder governance into firms was identified by Porter (1992: 15). Porter recommended that shareholders: "Nominate significant owners, customers, suppliers, employees and community representatives to the board of directors". Porter developed his recommendations from considering the practices found in Japan and Germany. What Porter overlooked was that stakeholder involvement in these countries was achieved by there being more than one board.

A single board accountable to many different interests becomes accountable to no one. It allows governance to become toxic as found in firms without a dominant investor to hold management to account on their systemic unethical conflicts (Turnbull 2000b: 115). This point is recognised and avoided in all non-trivial sustainable stakeholders controlled firms. A global survey of such firms by Bernstein (1980) reported that they all possessed multiple boards to introduce some separations of powers. This is an essential requirement to reduce or eliminate toxic governance (Turnbull 2014d, 2016).

The detailed governance architecture of five selected non-toxic stakeholder-governed firms are presented in Turnbull (2014b: 231-307). Various viewpoints and aspects of ecological governance are presented in Turnbull (2002a, b; 2012) with a generic form provided in "Figure 2, Generic llustration of network governance with stakeholders as co-regulators".

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Insert Figure 2 about here
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A simplistic generic illustration of introducing elements of ecological governance to hierarchical form of governance is presented in Figure 2. It introduces two crucial features to organisations: (1), A separation of the power to manage from the power to govern so as to eliminate absolute power and the systemic toxic conflicts of interest from unitary control, and (2) A requisite variety of formal outside in and bottom-up communication and control channels with stakeholders. This allows the identification and control of complexity as reliably as desired with stakeholders able to protect and further their own interests and those of the firm while reducing the role, size, intrusiveness, insensitivity and cost of government regulators whose prime role is to protect stakeholders.

As shown by VCs, there are no ethical commercial reasons for directors to obtain both the power to govern and the power to manage. While one vote per share is required to protect the property rights of investors to appoint the directors, the rights of minorities needs to be protected from oppression by large shareholders and/or their directors. This can be achieved by appointing a governance board on the basis of one vote per investor. The powers of the Board of Governors are those that are not required by directors to carry out management functions. Governance powers involve:

- Establishing Key Performance Indicators (KPIs) for directors;
- Co-nomination and remuneration of directors elected by shareholders;
- Co-nomination and remuneration of auditors elected by shareholders;
- Nomination, appointment, remuneration and control or influence of any other advisers to members/shareholders or chair of annual meetings to hold directors to account;
- Control of director elections and discretional proxies;
- Determination of director tenure;
- Determination of how directors manage any operational conflicts of interests.

To maximize the variety of distributed intelligence, data feedback, control initiatives and contestability of views, separate self-appointed representative bodies are required to represent the various common-interest groups of stakeholders. These could involve local, regional, national and global perspectives to provide independent crosschecking intelligence on the known knowns, the known unknowns with exposure to identifying the unknown unknowns.

Because of the diverse interests between stakeholders and between stakeholders and management network governance can introduce creative tensions with contested decision making just as occurs in the human brain from existential risks, opportunities and conflicting desires. Rather than forcing individuals into obedience, conformity and group think, network governance can constructively use individual contrariness to introduce contested decision making for the common good at the individual, group and entity level.

In these ways network governance introduce tensegrity to allow new emergent attributes to arise to cope with complexity more simply, innovatively, resiliently and comprehensively than its individual parts. These outcomes are denied in command and control hierarchies.

The division of powers allows contestability to arise within and between managers, directors, shareholders, governors, and with other stakeholder constituencies. Competition for control between stakeholders provides a more informed, economic, efficient and nuanced situation then being exposed to competition for control through a stock exchange. The advantage of this approach is that it can occur without organizations being publicly traded or even for the need for property rights to exist. This is the situation in non-profit corporations and incorporated professional associations. Pound (1992, 1993) has articulated other advantages of internal competition for control.

The stakeholder congress shown in Figure 2 connects individuals with the: (i) information to act; (ii) incentive to act; (iii) power to act; and, (iv) the capability to act, negotiate, protect and/or promote their individual and/or common interests. This “polycentric compound

republic" architecture allows well-informed, nuanced and expeditious identification of Key Performance Indicators (KPIs) to be developed by stakeholders for the Board of Governors to determine the pay and tenure of the directors. This arrangement forces directors to recognize the need to take into account the individual wellbeing of stakeholders interests but leaves to their discretion as to how this is achieved in the best interest of the corporation as a whole. In this way, individual interests that could lead to "the tragedy of the commons" can be avoided.

Further sources of tensegrity can arise from other ways of establishing a division of powers and influences. As a purpose of general meetings is to hold directors and governors accountable and determine their tenure and remuneration, it means that neither a director nor a governor should control the process. This is why Figure 2 suggests that stakeholders should nominate the chair of AGMs from either their own number or from members/stockholders of the corporation. This in turn generates interdependencies between the relevant stakeholders, as is in fact the case for the operating success of most enterprises. Also a formal governance framework is created for Just-In-Time (JIT) supply chain practices and Total Quality Control (TQC) of goods and services.

Stakeholders could also obtain the right to attend shareholder meetings to voice their views without a vote on the nomination, tenure and remuneration of governors who determine the tenure and pay of the directors. In this way, Governors could be encouraged to work out mutually beneficial ways in determining KPIs to protect and further the interests of both stakeholders and the firm. There exist other various ways for using a diversity of views to generate constructive tension to discover or invent processes for continuous improvements for all concerned including individual wellbeing and for the enterprise as a whole.

Ideally, the diversity of views within the architecture of networked governed firms should also be available to the firm as a whole. It is in this way that network governed entities can mimic the contrary character of holonic entities found in nature. There is a great variety of

ways in how network governed firms can be designed, but little research into firm specific details. The most outstanding example of how the architecture of a network governed firm can mimic the architecture of life and the universe is provided by the MCC. So closely does the MCC mimic nature that a "Holon Typology of Mondragon" was identified in Table 6.1 of Turnbull (2014b: 290). How the MCC represents a Hierarchy of Holons within a Holarchy of the universe is presented in Table 3.8 "Holarchy: Hierarchy of holons" in Turnbull (2014b: 167).

Thomas & Logan (1982: 126-127) reported the superior resiliency and operating advantages of the MCC. For other network governed firms Nohira & Eccles (1992), Craven, Piercy & Shipp (1996), Podolny & Page (1998) and Turnbull (2000a; 2002b) reported on their competitive and operating advantages to suggest that the benefits of network governance in relation to hierarchies increases with the complexity and dynamism of the environment and/or the activities of the firm. This supports the intuition that the governance architecture used in nature to survive complexity provides a superior approach for humans follow. The topic suggests many research opportunities. Some are considered in the following concluding Section with some closing comments.

**Research Limits, Agendas and Conclusions**

The discussion presented above on how the architecture of corporate governance affects the wellbeing of individuals and their organizations is an under-researched topic. One reason is that they're relatively few network-governed corporations. Their economic impact is trivial. However, their individual operating performance has been impressive.

Networks of non-profit incorporated and/or non-incorporated association are more common. Examples are the Red Cross, surf life-saving organizations, scouts, hobby and cultural associations, business service organizations and sporting bodies. Omitting the word "corporate" to simply focus on the governance of organizations creates a more significant

research area. Most unincorporated associations and networks have some form of constitution defining how their decision-making processes, communications and control systems operate.

One important point neglected in this paper is the existence of a body corporate. It introduces the complication of creating a new entity that is different from its directors or members. A justification for this neglect is that a corporation is a social construct. However, the entity technically introduces additional conflicts of interests between the entity, its stakeholders and society to be considered. While important they represent a second order concern from the perspective of the OECD developing metrics on individual wellbeing.

Individual wellbeing could be subject to the governance architecture of all types of social institutions, whether or not they involved with families, clans, tribes, associations, networks, firms, markets or other forms of relationship in the private, non-profit or government sectors (Ben-Porath 1978). This supports the view that future research should not be restricted to incorporated bodies.

The OECD (2015: 23) changed the application of their framework shown in Figure 1 from "individual" to the less specific but more general description of "current" wellbeing (OECD 2017: 22). The Chapter 4 of either version states that governance affects wellbeing but recognizes that there is no agreed framework for collecting governance statistics. Neither version of the OECD document cites Ostrom or considers "inclusive" organizations like those proposed by Roberson (2018), Fink (2018) and described in this article as "ecological".

Wellbeing in nature requires living things to survive and reproduce in their environment. This is dependent upon self-regulation of the individual and self-governance of the specie. Self-governance of specie, may involve support from other species. The determinants of self-governance, creates a fundamental criteria for the OECD to determine wellbeing for both individuals and organizations. This means that it is not statistics on governance that is required but on the three basic conditions required to facilitate self-governance (Turnbull

2000b: 118) tabulated in "Table 3.7, Evaluation of hierarchies to control, regulate or self-govern" and avoid: "The corrupting powers of an unitary board" (Turnbull 2000b: 115). The OECD (2017: 178) cites the view that "corruption is the opposite to good governance" and that corruption can reduce wellbeing. But the OECD, (2015a) has no definition of good governance, only practices, that accept corruption of an unitary board (Turnbull 2004).

Natural systems could fill this void for the reasons described above. This approach would require the OECD to reframe its "Principles and Processes" described in its "Table 4.1 Selected and domains and dimensions of governance statistics" (OECD 2017: 161). This would allow the word "Trust" in public institutions as an "outcome" to be replaced with "Tensegrity". An integrated coherent framework could then be established, explainable and accepted as being consistent with the laws of nature.

Another reason inhibiting research into firms controlled by more than one board has been the lack of methodology to undertake the task as noted by Radner (1992: 1384). This has now been overcome by the development of TBA. Bytes involve perturbations in energy and/or matter. So TBA provides a basis for grounding social interactions in the natural sciences to establish a science of Governance and specifically a science of corporate governance (Turnbull 2002c, 2008). While the social constructs of information, knowledge and wisdom cannot be objectively metered like bytes, no change in these constructs can occur without the transaction of bytes within and between humans and/or other species.

Technology now routinely measures bytes involved in written, verbal and visual communications to provide a basis for empirical research into comparing the data intensity of using hierarchies, networks and/or other integrative mechanisms for governing society. The limited ability the human physiology and brain to receive, store, process and transmit bytes has now be measured to allow researchers to identify when data overload and "bounded rationality" (Williamson 1975: 4) arises. Tools now exist for empirically investigating the

differences in efficiency and reliability of alternative governance architectures. This could allow new designs to be developed and tested. A basis could be developed to evaluate the extent that the governance architecture of organizations is best fit for their purpose. This in turn could provide a basis for evaluating both organizational and individual wellbeing.

Because hierarchical governance is so dominant future research could introduce profound changes for both the theory and practice of governance. Governance is about the exercise of power so the OECD metrics may also provide a basis for improving the wellbeing of democracy.

Hopefully this paper may motivate others to undertake a much more detailed and deeper research into the issues raised.

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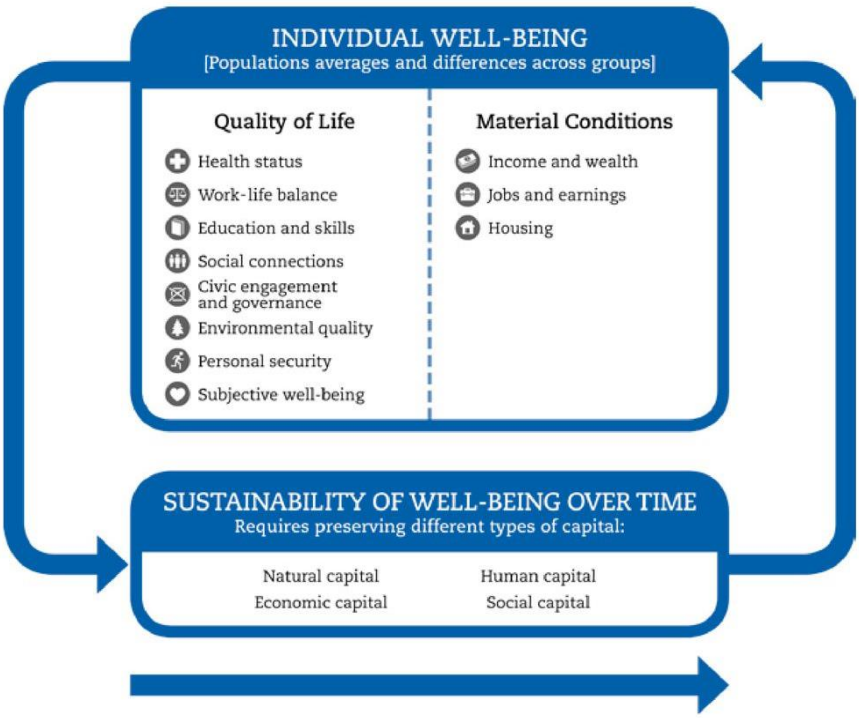
**Figure 1**

**The OECD framework for measuring individual wellbeing**

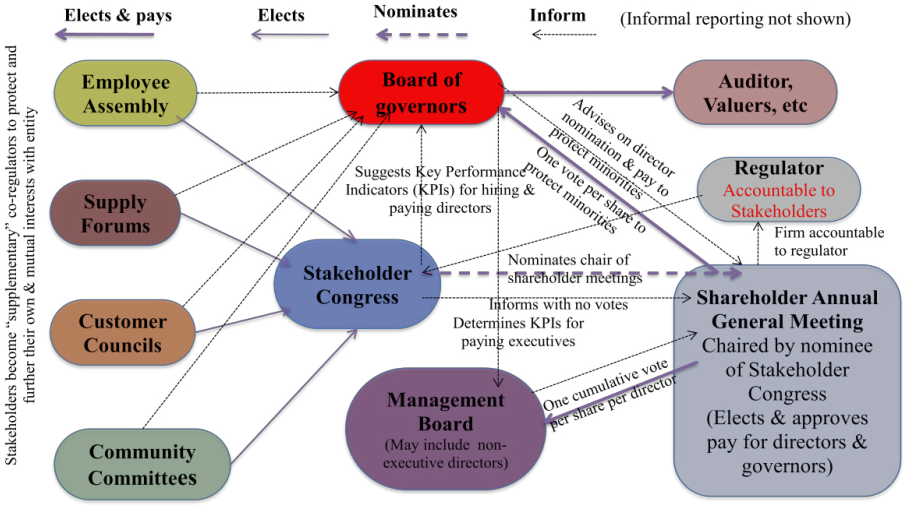



Source: OECD 2015. ***How's life? Measuring wellbeing: 23***. OECD publishing: Paris. <https://read.oecd-ilibrary.org/economics/how-s-life-2015_how_life-2015-en - page1>

**Figure 2**

**Generic illustration of network governance with stakeholders as co-regulators**

Separation of governance powers from management allows independent bottom-up and outside-in stakeholder intelligence to integrate governance into Corporate Social Responsibilities to monitor and control misconduct while protecting and furthering the interests of stakeholders, the firm and society with less costs




For publicly traded, large private firms, non profits and government corporations

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## 7.2 G2. Estado y reforma enérgetica en México - Marco Antonio Merchand Rojas

1

### Estado y reforma energética en México

MarcoAntonioMerchandRojas

**Resumen.**

Este ensayo analiza, cómo las reformas en el sector energético emprendidas por el gobierno de Peña de Nieto (2012-2018) representan la culminación de un Estado, que no está interesado en salvaguardar el patrimonio territorial, es el propio Estado, quien aplica la acumulación por despojo[1] para beneficio de los particulares, sobre todo de las transnacionales que ganan licitaciones en megaproyectos energéticos -termoeléctricas- (petroleras, mineras, telecomunicaciones, etc.). El Estado favorece el despliegue de la acumulación del capital a favor de la lógica de la cadena de valor global en las actividades más diversas: energéticas; agropecuarias; inmobiliarias e incluso turísticas.

[1] David Harvey, ilustra notablemente en la declaratoria final, de las Jornadas Nacionales en Defensa de la Tierra, el Agua y la Vida, celebradas en Atenco, México (Estado de México) el 16 y 17 de agosto de 2014: "El despojo es una realidad cotidiana que padecemos todas y todos: despojo de la tierra, del agua, del aire, de la biodiversidad, de nuestros saberes, del patrimonio familiar y comunitario, de los bienes comunes, de nuestros derechos individuales y colectivos, de nuestros sueños y nuestras esperanzas… Nos despojan los proyectos mineros, las represas, las carreteras y ductos. Nos imponen urbanización desordenada, desarrollos turísticos, privatización de los servicios básicos, se adueñan de la biodiversidad y le ponen precio, comercializan y empobrecen nuestra riqueza cultural" (Harvey, 2004)

**Introducción.**

A lo largo de este trabajo, se analiza cómo el Estado allana el camino a todo tipo de inversiones a través de las privatizaciones de los activos públicos que legalmente están a su resguardo, con el estilo de desarrollo neoliberal se instrumenta la venta de estos activos (privatizaciones) y se empieza a operar de esta forma; una devaluación masiva de sus activos (agua, petróleo, minas telecomunicaciones, transporte, sistema de provisión social, etc.). Para alcanzar este objetivo general, la exposición se ordena a partir de plantear el alcance epistémico y la conjetura que sustenta este trabajo, también se explica cómo se concretiza el concepto de acumulación por desposesión en México y por último, se explica la transnacionalización a lo que va estar sujeto el sector enérgico, después de las reformas implementadas en dicho sector.

**Planteamiento metodológico del objeto de estudio.**

Respecto al planteamiento metodológico sobre el estado del arte objeto de estudio, se plantea una visión epistémica que sustenta la premisa de que al implementarse reformas en el sector energético; éstas tienen el objetivo sustancial de reconfigurar el territorio a partir de las necesidades del capital transnacional, a través de espacios nacionales y/o locales.

La hipótesis que sustenta este análisis, es que el Estado opera a favor de los capitales extranjeros, mercantilizando los bienes naturales, es decir, cosificándolos y transformándolos en propiedad privada para poder apropiarse de ellos. El Estado instrumenta la acumulación por desposesión (despojo), siendo éste un ejercicio de poder que se ha expresado en el devenir histórico del capitalismo, aunque esta acumulación por despojo, cobra fuerza ideológica a partir del modelo neoliberal y representa, sino la única forma, si la más importante actualmente para sostener o incrementar la acumulación de capital en la geografía global a través de apropiarse de los espacios locales y/o regionales.

Estos espacios locales y/regionales se privatizan y son acotados ahora por intereses extranjeros (inversiones transnacionales), esto es gran medida, porque ya el Estado, no es soberano (el Estado ya no toma sus propias decisiones para defender el territorio nacional de intereses extranjeros), el Estado, ahora sólo es una instancia promotora de dichas inversiones extranjeras (Garay, L et al; 2013). Estos espacios desgobernados que se caracterizan por tener

un Estado ya “no soberano” y que decide no regular y/o acotar a las actividades extractivas de las trasnacionales, caracteriza la etapa actual de la globalización neoliberal (Garay, 1999).

Esta práctica de la globalización neoliberal, ocurre cuando los espacios de un territorio nacional, local y regional de un país, se privatizan y éstos cada vez están más expuestos a externalidades negativas por parte de capitales extranjeros.

En síntesis, un rasgo distintivo de globalización o de la economía política global, se expresa, en un proceso de titularización de bienes agrícolas y recursos naturales en los mercados mundiales de capitales. Este concepto de un mercado mundial de capitales, adquiere relevancia a partir de una multiplicidad de formas de dominación, cómo es a través de la adquisición masiva de tierras; el licenciamiento extensivo del subsuelo para la explotación de recursos naturales no renovables; la implantación de modalidades para la mercantilización del uso de la tierra, cómo el Derecho Real de Superficie (DRS). La generalidad que adquiere este mercado de capitales; es el acaparamiento del uso del suelo y del subsuelo y/o en la propiedad de tierras, en países en desarrollo por parte de capitales extranjeros (Garay 2013).

El que alecciona bien lo explicado arriba, es David Harvey (2014) en su reciente libro: “Las diecisiete contradicciones y el fin del capitalismo”. Este explica con un ejemplo; lo acontecido en el 2008 con la crisis financiera y dice, que el: Valor de uso y valor de cambio (con el crash de la vivienda en Estados Unidos, millones de personas fueron desposeídas de sus casas –valor de uso– por la especulación, o sea el elevado valor de cambio). David Harvey, completa lo explicado más arriba, los poderes y prácticas del Estado, han estado cada vez más dirigidos a satisfacer las demandas de las empresas y los accionistas, a menudo a expensas de los ciudadanos. Esto implica un fuerte apoyo del Estado a la creación de un buen clima de negocios, favorable al capital. El resultado es, en muchos casos, que a los Estados les puede estar yendo muy bien, mientras que a sus poblaciones les va muy mal.

Asimismo, habría que explicar que dentro de las primeras contradicciones funcionales analizadas por David Harvey, es la contradicción (propiedad privada y Estado capitalista, la que nos interesa destacar). Harvey explica que esta contradicción, se crea una diferencia entre lo que se llaman derechos de usufructo (que corresponden al uso activo) y derechos de propiedad exclusiva permanente. Esa diferencia ha sido a menudo fuente de confusión, en

particular en toda la historia del colonialismo. Las poblaciones indígenas funcionan con frecuencia sobre la base del derecho de usufructo de la tierra, por ejemplo (como sucede en el caso de la agricultura itinerante). Las potencias coloniales impusieron casi siempre derechos de propiedad excluyente, lo que fue y sigue siendo origen de muchos conflictos. Las poblaciones que se movían de un lado a otro siguiendo a sus ganados o desplazándose de tierras exhaustas a otras nuevas y más fértiles, se encontraban de repente impedidas de utilizar tierras que habían considerado tradicionalmente a su disposición, porque ahora estaban cercadas y rodeadas de alambre de espino por alguien que las poseía perpetua y absolutamente, aunque no las utilizara.

Además, la imposición de estos derechos de propiedad privada depende de la existencia de poderes Estatales y de sistemas jurídico-legales (usualmente acoplados con los de recaudación impositiva en forma monetaria) que codifican, definen y hacen valer las obligaciones contractuales que corresponden al derecho de propiedad privada y a los derechos, de los sujetos jurídicos individuales, es más, existe una contundente evidencia de que el poder coercitivo del Estado desempeñó un importante papel en la apertura de espacios en los que pudiera florecer el capital mucho antes de que se hicieran dominantes los regímenes de propiedad privada.

El mismo, David Harvey añade a su comentario, que actualmente la erradicación de los derechos de usufructo y los odiosos procesos de cercamiento de los bienes comunes, han hecho posible el dominio de un sistema de propiedad privada individual irrestricta, respaldado este dominio, por el poder del Estado. Como garante de esos derechos de propiedad privada, se apela al Estado, con su monopolio del uso legítimo de la fuerza y la violencia, para evitar o reprimir cualquier transgresión del régimen de los derechos de propiedad privada individualizada. El Estado capitalista debe usar el monopolio adquirido sobre los medios de violencia para proteger y preservar ese régimen, tal como se articula en el funcionamiento «libre» de los mercados.

Por cuestión de espacio, no podemos proseguir la discusión sobre la importancia del Estado en el modelo neoliberal, habiendo una serie importantes autores y perspectivas teóricas[2] sobre

[2] No se cuenta con una teoría del Estado consistente y unificada; esta no se encuentra incluso, en los clásicos del Estado (Weber o Marx), ni por supuesto, tampoco en los desarrollos posteriores, ya sean

el papel que asume el Estado, aquí se destaca la asumida por Robert Jessop (2008) quien también refleja el cambio experimentado por el Estado; del Estado de bienestar (welfare) al Estado de trabajo (workfare), donde el aparato organizador y legitimador y coercitivo estatal se pone al servicio ya no de la inclusión social y del aumento de la calidad de vida de los ciudadanos sino de la competitividad de las empresas en la arena internacional o cómo decía Ralph Miliband (1978); el Estado es un instrumento de la clase dominante, aunque es una formulación compleja que no debe ser leída en forma lineal.

En el siguiente apartado, se específica más el concepto de acumulación por desposesión (despojo) que es un elemento clave por pate del Estado para que los recursos naturales se los apropien, el capital, tanto nacional, como extranjero.

**La acumulación por desposesión (despojo).**

Antes de analizar con mayor profundidad, la acumulación por desposesión, también llamada acumulación por despojo y/o acumulación originaria se hace indispensable remitirse a los autores (De Angelis, Bonefeld, Composto) que ubican el concepto a partir del planteamiento de nuevos cercamientos[3] y que incluso, el propio Harvey hace referencia en sus libros.

Por cuestiones de tiempo y espacio no se entrara a reconstruir los debates y polémicas generados dentro de la tradición marxista sobre el concepto de acumulación por desposesión empleado por Harvey (2007), no es la intención detenernos en este caso; en toda la espesura teórica de estos debates y conceptos. La intención es sólo referenciar brevemente el concepto de acumulación originaria que se ilustra a partir de la entrevista que le hace Claudia Composto y Mina Lorena a John Holloway. La pregunta trazada por Claudia Composto y Mina Lorena recobra el planteo de Massimo De Angelis, quien sostiene:

> "Que la acumulación originaria es un proceso inherente y permanente incluso en las sociedades del capitalismo maduro, que se expresa mediante la continuación de la separación violenta entre las personas y, no solamente sus medios de producción, sino sus condiciones de vida en general, lo que podríamos denominar "lo común"; y

en la tradición pluralista o marxista. Lo que existe son diferentes aproximaciones, cada una con diferentes propósitos y diferentes contextos históricos, que una forma eventualmente iluminada se complementan unos con otros.

[3] Con el término cercamiento (enclosure en inglés) se refiere al cierre de los terrenos comunales (tierra demanial) a favor, de los terratenientes ocurrida en Inglaterra entre los siglos XVIII y XIX.

> sostiene que, por ejemplo, el neoliberalismo es una expresión actual de la acumulación originaria, en tanto ha avanzado sobre formas comunitarias, territorios, relaciones sociales que estaban por fuera de la órbita del mercado como resultado de luchas sociales históricas" (Composto, C y Lorena, M 2012: sin/página).

En síntesis, para Holloway es más útil pensar el despojo en términos de una estrategia para superar la crisis de la explotación, y no como otra forma de acumulación. Si decimos que el capital depende, no solamente de la explotación del trabajo, sino de la explotación cada vez más acelerada, cada vez más intensa del trabajo. La postura de John Holloway coincide con la expuesta por (Massimo De Angelis 2012) quien sostiene que el capital despliega procesos de acumulación originaria ex novo que profundizan la privatización y mercantilización de lo común, toda vez que el trabajo se erige como un obstáculo para su reproducción y genera rigideces en la dinámica de la acumulación. De Angelis sostiene que la acumulación primitiva no puede ser reducida a un acontecimiento histórico pasado, sino que se encuentra necesariamente presente en los sistemas capitalistas "maduros" como proceso inherente que, dada la naturaleza conflictiva de las relaciones capitalistas, asume un carácter continuo.

En la misma tesitura, el propio Bonefeld, W (2012) detalla más el concepto, se ha argumentado que la acumulación primitiva es una acumulación reproducida en forma constante, ya sea en términos de renovada separación de nuevas poblaciones de sus medios de producción y subsistencia, o en términos de la reproducción de la relación salarial en las relaciones "establecidas" del capital. La primera busca llevar nuevos trabajadores bajo control del capital y la segunda, contenerlos allí como categorías sociales "liberadas" de sus condiciones.

Es precisamente a partir de la reconstrucción y/o renovación de la acumulación originaria; la importancia que tiene el autor Italiano De Angelis de replantear la acumulación del capital como una política de "nuevos cercamientos" y privatización de bienes comunes acontecida en las últimas dos décadas tanto en vastas regiones de Europa Occidental como en casi la totalidad de América Latina.

Este rasgo de privatización que cobra fuerza con el neoliberalismo y que explica muy bien David Harvey en su libro "Nuevo Imperialismo", se expresa en continuas privatizaciones de espacios comunales, activos públicos, bosques, lagos y montes a lo largo y ancho, de nuestro continente, estas privatizaciones deben leerse como parte de una amplia estrategia de

acumulación capitalista, basada en mecanismos predatorios que buscan convertir estas instancias vitales y bienes comunes en productos con alto nivel de rentabilidad. Y precisamente a partir de aquí, que llegamos el punto nodal de este trabajo; que es analizar cómo esta alta rentabilidad está a cargo de las transnacionales, siempre y cuando sean afianzadas con el apoyo irrestricto de lo que se ha llamado "Estado nacional de competencia" que, en tanto entidad responsable de crear el espacio para la acumulación, se convierte en socio de la desapropiación, pero en una posición asimétrica de sesión frente a los intereses transnacionales.

Un ejemplo que se acomoda perfectamente, es a lo explicado por Claudia Composto (2012) que recalca de cómo otorgar garantía a la continuidad de la reproducción ampliada por parte de los países periféricos; es el de la ofensiva extractivista que implicó la creciente integración subordinada de las economías de la periferia al circuito de la gran producción capitalista global expresado en el nuevo carácter de la dependencia y los procesos de recolonización característicos de las últimas décadas (Seoane, J 2012).

Es en los países de América Latina donde se instaura un proceso que se denomina "ofensiva extractivista", definido como un perene ciclo de profundo y acelerado avance de la expropiación, mercantilización y depredación de los bienes comunes naturales de la región, en tanto estrategia del capital frente a la crisis global de acumulación que suscribe actualmente al sistema (Seoane, J 2012).

Ahora, por lo que respecta a la acumulación por desposesión (Harvey, 2004) concepto central que se utiliza en este trabajo. Dicha acumulación por despojo cobra fuerza ideológica a partir del modelo neoliberal y representa, sino la única forma, si la más importante actualmente para sostener o incrementar la acumulación de capital en la geografía global (lograr el *establishment* del sistema bancario y de las grandes corporaciones y centros de poder -BM-FMI y BCE[4]).

El rasgo económico-político que definiría, dicha acumulación por desposesión, es que su instrumentación para llevarse a cabo, necesita obligatoriamente que el Estado y los dueños de capital (productivo, comercial, financiero) tengan el interés común "contubernio" de que

[4] BCE (Banco Central Europeo)

los espacios receptores sirvan para que el capital incremente su capital; esto sólo se logra expropiando el derecho del trabajador de vivir dignamente con un empleo bien remunerado. En palabras de David Harvey, quien posibilita la acumulación por desposesión es la liberación de un conjunto de activos, incluida la fuerza de trabajo a un coste muy bajo y en algunos casos, nulo.

David Harvey (2007) ha ayudado a comprender la importancia del concepto de acumulación de capital que se hace necesario estudiarlo sobre todo cuando él capitalismo ha experimentado una transición entre el viejo modelo de acumulación a uno nuevo. Harvey D (2007) caracteriza el fordismo; cómo el viejo modelo (la cadena de montaje de producción en masa, la organización política de masas y las intervenciones del Estado del bienestar) y, la acumulación flexible (el nuevo modelo) que se caracteriza en general por la búsqueda de mercados especializados, opera la descentralización unida a la dispersión espacial de la producción y, una retirada del Estado-nación de las políticas intervencionistas propiciando la liberalización y privatización de los activos del Estado.

Es también, el Estado que gracias a su monopolio sobre el uso de la violencia y su definición de la legalidad, desempeña un papel crucial tanto en el apoyo como en la promoción de estos procesos. Ante este listado de mecanismos, se debe añadir la extracción de rentas de las patentes y los derechos de propiedad intelectual, y la disminución o la anulación de varias formas de derechos de propiedad comunes (como son las pensiones del Estado, las vacaciones retribuidas, y el acceso a la educación y a la atención sanitaria).

En el mismo tenor que lo explica David Harvey (2007); la competencia entre los diferentes territorios (Estados, regiones, o ciudades) por poseer el mejor modelo de desarrollo económico o el "mejor clima para los negocios", era una cuestión relativamente insignificante en la década de 1950 y de 1960. Sin embargo, la contienda entre territorios y/o países por atraer capitales (Estados-nación que incentivan que promueven la entrada de capitales -IED directa e indirecta-) se intensifica después de 1970 con la puesta en marcha de un modelo neoliberal que ha propiciado a la larga un desarrollo geográfico mundial más desigual en términos de un proceso de acumulación por desposesión y que tiene su equivalente con el de la apropiación del espacio y, esta apropiación puede ser ejecutada por

un imperialismo formal e informal dependiendo de intensidad de la dominación; sea violenta o disimulada (Wallerstein, I 1988).

También se completa dicha explicación con el argumento:

> "Hay que destacar la importancia que cobra y se le exige a los Estados-nación, favorecer *el despliegue de la acumulación del capital* en la lógica de la cadena de valor global en las actividades turísticas, agrícolas, mientras e industriales. En otras palabras, como lo explica Harvey, D (2004) la soberanía Estatal sobre la circulación de mercancías y capitales es entregada en una actitud servicial al mercado global. El quid del asunto, para David Harvey se encuentra en la soluciones espacio-temporales, porque generan demanda, tanto de inversión como de bienes de consumo en otros lugares (ejemplo; la actividad turística). Incluso extendiendo más el concepto sobre el despliegue de la acumulación de capital, el petróleo y otros recursos geoestratégicos de México, incluida la tierra como mercancía, están incluidos entre los objetivos neocoloniales de Washington y el capital corporativo trasnacional, plasmados en la Alianza para la Seguridad y la Prosperidad de América del Norte" (Merchand. M 2012 b: 37-38).

Se ha dicho de una y otra forma que la acumulación por desposesión no puede implementarse sin el apoyo irrestricto del Estado y que éste ha sido un actor central en los cuatro aspectos que cubre la acumulación por desposesión (privatización y mercantilización, la financiarización, la gestión y manipulación de la crisis y redistribuciones de la crisis). Siendo el Estado, empleador de la violencia y hacedor de la legalidad, es evidente que todo proceso económico que implique manejo de recursos económicos y/o activos financieros pasa por su tamiz para cubrir el despojo jurídicamente, pues hay que recordar que el Estado es un poder de clase que se expresa en flexibilizar las leyes (desregulación) para que las distintas denominaciones del capital se adueñen de los recursos productivos y financieros de sus territorios y, así permitir que el capital aproveche las condiciones desiguales en la economía espacial en términos de distintas dotaciones de recursos diferenciales en el ámbito nacional, regional y local.

Cabe insistir, que los elementos de análisis que integran el concepto de acumulación por desposesión, deberían de abarcar en primera instancia, analizar la noción de espacio geográfico, como una relación de fuerzas políticas entre la tensión a nivel mundial y nacional. La perspectiva asumida, supone que el actual escenario mundial refleja la relación dialéctica

de dos lógicas de poder: la territorial y la capitalista (Arrighi, A)[5]. La relación entre estas dos lógicas debe entenderse de modo conflictivo -y con frecuencia contradictorio- más que de forma funcional o unilateral, en cuanto al Estado y el capital estos siguen conformando y articulando relaciones de conveniencia económica-política que empaten los intereses de las dos lógicas descritas

Luego entonces, se considera la composición de esas dos lógicas o vectores aludidos (la territorial y la de capital), en términos de poder. Por un lado, se tiene el interés de Estados Unidos -en cuanto Estado-nación que detenta una política de *poder estado-imperial* como proyecto político específico de amplio alcance, propio de agentes cuyo poder se basa en el control sobre un territorio frente al resto de los Estados nación del continente, asegurándose al mismo tiempo este Estado imperial de una importante porción geográfica del mundo de cara a las disputas con otros bloques de poder de acuerdo a la división del poder mundial.

El Estado para garantizar la reproducción del capital global, crea, un espacio jurídico para las corporaciones transnacionales por encima de la soberanía Estatal, cómo es el caso de las transnacionales petroleras que se instalaran en territorio mexicano.

**La reforma energética favorece a la inversión extranjera**

La pregunta que hay que hacerse de inició, es por qué el Estado actúa de la manera que lo hace y una de la razones, es que desde los años setenta, y hasta el día de hoy, la economía de los países desarrollo han sido dominadas por el enfoque neoclásico impuesto por los neoliberales[6], donde los operadores mundiales de tal modelo, son los dos Organismos Financieros (FMI y BM) que sustentan el liderazgo de los Estados Unidos. El

[5] Cita de Harvey (2004:39), Arrighi nos explica que las lógicas de poder denominadas "territorial" y "capitalista" son muy diferentes entre sí. Harvey agrega y señala que la relación entre ambas lógicas debe entenderse por lo tanto, como algo problemático –y con frecuencia contradictorio (esto es dialéctico)- más funcional o unilateral.

[6] Los neoliberales, que dominan el escenario económico y político actual, sostienen, en principio, que el "Estado" ha de tener una actuación mínima y reducirse a mantener un marco propicio para la actuación del sector privado. Afirman que de esta manera el sector privado tendrá un contexto de mayor estabilidad, más beneficios y mayores estímulos para su actuación. De acuerdo con estos planteamientos los neoliberales sólo consideran adecuada la intervención para mantener "la ley y el orden", que quiere decir principalmente el garantizar la propiedad privada y apoyar los negocios. Concluyen, que tanto el gasto público debe ser lo menor posible, así como los impuestos que tengan que pagar las personas y los beneficios de las empresas.

condicionamiento que ejercen estos Organismos Internacionales sobre el accionar de la política económica de los países, es con el cometido de afianzar y reproducir exitosamente los capitales productivos, comerciales y de servicios de carácter global en sus economías nacionales. De ahí, de que uno los principales desafíos de la política económica, es que toda intervención de política garanticé a toda costa otorgar garantías al capital productivo y financiero.

Esto es, la mayoría de los gobiernos de América Latina, con diferente énfasis, insisten en insertarse en la economía global, lo cual inevitablemente exige, que se eliminen las regulaciones, trabas y costos en el comercio de bienes y flujos de capitales. Este proceso de globalización lleva al dilema de redefinir el papel de Estado-nación, aplicando medidas para atraer inversiones y promover exportaciones. En las últimas décadas, a partir del inicio del neoliberalismo y el auge de la globalización, América Latina registra un proceso de «desestatalización» del Estado, por el cual este es despojado de sus atribuciones principales, es así como el Estado ha sido progresivamente despojado de su función de gobernar. No solo ha perdido su eficiencia gobernante, sino que también ha confundido y cambiado los modos de gobernar, y ha dejado de ser un organismo e instrumento de gobierno.

Por ejemplo para la atracción de los capitales internacionales, se reducen los estándares, laborales, se otorgan excepciones fiscales y sobretodo se brinda estabilidad macroeconómica (tipo de cambio estable, tasas de interés altas respecto a la internacional) que brinde condiciones seguras al capital productivo y financiero.

Respecto el caso de México y en relación al Estado capitalista neoliberal mexicano; éste puede ser ejemplificado y caracterizado por las recomendaciones que emite el Tribunal Permanente de los Pueblos (TPP)[7].

[7] El Tribunal Permanente de los Pueblos (TPP), fundado en 1979, es heredero del primer tribunal creado por Bertrand Russell para juzgar los crímenes cometidos por el gobierno estadunidense en la guerra contra Vietnam, y del tribunal que se organizó con Julio Cortázar para juzgar a la dictadura militar argentina. Ahora, el TPP ha sesionado en México bajo el título Libre Comercio, Violencia, Impunidad y Derechos de los pueblos en México, en cuyo marco se han realizado diferentes audiencias frente a jueces internacionales y nacionales determinados por el propio TPP (TPP 2014).

El Estado mexicano, como de muchos otros Estados en América Latina, han implementado desde mediados de los ochentas, políticas públicas y programas de gobierno centrados en todo tipo de despojos de los bienes públicos y de los bienes comunes de los pueblos. El objetivo de este despojo y/o por acumulación por desposesión que aplica el Estado, ha consistido en implementar un modelo extractivista, no apoyado sólo en la explotación del petróleo, sino en un extractitivismo energético que incluye gas convencional, gas shale, viento, energía solar y por supuesto también minero e incluso hidrológico, estos recursos naturales están actualmente controlados por empresas petroleras y gasíferas, sobre todo de capital estadounidense, y en el caso de minería, de capital canadiense.

Para Saxe, John (2002), se han instrumentado mecanismos militares y financieros por parte de Estados Unidos de América para garantizar el despojo de los recursos estratégicos, no sólo de México, sino de la gran mayoría de los países latinoamericanos. Esta descripción muestra la condición secular México, primero como colonia y después como país periférico y, que nos coloca históricamente bajo presión geopolítica y económica. Se registra históricamente, una transferencia al exterior de una buena cantidad de riquezas expresadas en mecanismos financieros a través de permanentes pagos de deudas internacionales, también de mecanismos comerciales de intercambio desigual y de una explotación desmedida de recursos naturales por parte de empresas extranjeras.

Esta forma de operar del Estado mexicano de concesionar y/o vender recursos naturales que pertenecen a la nación a intereses espurios (empresas trasnacionales, que sólo explotan irracionalmente los recursos naturales), significa invertir el orden institucional que se había construido con base a la constitución mexicana de 1917. Esta actitud distorsionada empleada por el Estado neoliberal, en el que usa sus atribuciones y poderes para garantizar posiciones de privilegios, no sólo a una oligarquía nacional, sino directamente a una oligarquía internacional, principalmente estadounidense.

En otras palabras, este Estado, que no cumple con deberes de defender la soberanía nacional y permite que las riquezas nacionales queden en manos monopólicas de un cerrado grupo de empresas transnacionales; se le califica como una conducta de “desviación de poder

económico[8]". Para concretizar, está "desviación de poder económico" el Estado emplea sus instituciones legitimadoras a través de instrumentación de leyes y normas (reformas energéticas), con el fin de beneficiar a poderosos interés particulares, certificado así, el despojo de los recursos naturales que pertenecen originariamente al pueblo.

En México, algunas de las situaciones y casos que claramente ilustran la "desviación de poder", son:

-La instrumentación de las instituciones públicas para favorecer intereses de las élites económicas y políticas a través de múltiples simulaciones jurídicas.

-El desmantelamiento de la constitución mexicana de 1917 a través de contrarreformas neoliberales durante los últimos cinco sexenios.

Esta "desviación de poder", se muestra ya en el sexenio de Carlos Salinas (1988-1994), quien envía una reforma para modificar el artículo 27 de la Constitución[9] y que sin duda representa la reforma social más importante de las leyes agrarias del país. Dicho cambio jurídico al artículo 27, permite que bajo determinadas circunstancias, ocurra la compra-venta, el arrendamiento y otras concesiones de la tierra, algo que estaba prohibido en la legislación anterior. La privatización y la desnacionalización en el modelo neoliberal empieza operar

[8] "En México, la desviación de poder es una figura desconocida. En un par de resoluciones recientes, la Suprema Corte de Justicia reconoce la figura como una hipótesis plausible. La primera Sala de la Corte, habla de la desviación y exceso de poder como un uso distorsionado de atribuciones discrecionales, uso que por ello, se convierte en arbitrariedad. En España la figura esta prevista expresamente en la legislación desde 1956. La nueva ley reguladora de la jurisdicción contenciosa administrativa número 29/1998 define la desviación de poder como el ejercicio de potestades administrativas para fines distintos de los figados en el ordenamiento jurídico" (TPP 2014/15)

[9] La reforma al artículo 27 y su ley agraria permiten el diseño de políticas públicas que buscan eliminar la propiedad social en los hechos. Como lo es el caso del Programa de Certificación de Derechos Ejidales y Titulación de Solares (PROCEDE) el cual fomenta la mercantilización y privatización de las tierras de ejidos y comunidades que adoptan la figura jurídica de "dominio pleno". Modalidad que suprime el carácter "imprescriptible, inalienable e inembargable" de las tierras Dominio pleno que se orienta a la fragmentación y titulación de manera individual de las tierras y territorios comunales y fomenta su incorporación al mercado de tierras. Tierras que pueden ser vendidas, hipotecadas y embargadas, así como arrendadas a empresas, modificando las diversas estructuras espaciales históricas que han construido los indígenas y campesinos en sus tierras y territorios por un lado; así como la destrucción de las asambleas comunitarias, que son la institución social que rigüe y regula la vida al interior de los ejidos y comunidades como máximo órgano de autoridad. ejidales y comunales que se tenía antes de la reforma de 1992.

con la entrega integral de recursos naturales estratégicos (partes importantes de la industria petrolera, electricidad, minería metálica, agua y biodiversidad), incluso de infraestructura estratégica (ferrocarriles, puertos marinos, líneas de cabotaje y áreas, de navegación de altura, red satelital, etcétera).

Alejandro, Nadal, A (2013) explica con apreciación justa, lo acontecido, pues parece que la única tarea de los gobernantes consiste en imponer esquemas de dominación sobre las mayorías para beneficiar a unos cuantos. En contra de toda lógica económica y política, se impuso al pueblo de México la decisión de entregar el sector energético a las empresas trasnacionales que nunca ocultaron su apetito por los yacimientos de hidrocarburos en el espacio económico mexicano. Así que la reforma consiste en re-abrir las puertas a las empresas que fueron expulsadas de esta industria en 1938. Aquí cabe otra abjetivitización, que hace (William Robinson, 2013), sobre el Estado que se adapta para manejar una economía liberalizada dominada por los intereses del capital transnacional. Es decir, en sus propias palabras, "la transnacionalización del capital se transnacionaliza sobre la base sobre la cual los funcionarios del Estado y la élite política realizan su producción". Sin embargo, esto no quiere decir que el capital ya no necesita al Estado para crear y mantener las condiciones necesarias para su expansión, sino más bien "el sistema de Estados nacionales, compuesto de unidades discretas interactuando entre sí, ha dejado de ser el principio organizador del desarrollo capitalista".

Esta regresión destruye componentes fundamentales del Estado mexicano tal y como éste emerge de la Revolución. El control sobre los recursos naturales había sido hasta ahora uno de los aspectos más importantes en la lucha por alcanzar independencia y desarrollo. Por eso seguía siendo uno de los principios esenciales en la Constitución de 1917. Y si los gobiernos que se fueron sucediendo a partir de los años 80 abandonaron el proyecto de alcanzar el desarrollo económico, los preceptos constitucionales sobre control patrimonial de los recursos naturales no perdían validez y servían para recordar lo que podría ser el camino del desarrollo económico. Hoy esos preceptos han sido desfigurados y el retroceso histórico ha reemplazado a la promesa del desarrollo. Las mismas instituciones que en teoría debieran velar por los intereses nacionales, son las que sirvieron para acelerar los trámites de la traición.

Desde el gobierno de Vicente Fox, el extractivismo energético, se instrumenta a favor de la privatización y otorgamiento del recurso petrolero y sus derivados a empresas transnacionales estadounidenses (Shell, Halliburton, Schulemberger). De acuerdo al artículo periodístico de Alfredo Jalife-Rahme (2014)[10], las empresas Estadounidenses han posicionado a las cuatro megapetroleras globales –ExxonMobil, Chevron, Shell y BP– como las principales beneficiadas de la reforma energética, mediante la cual el "México neoliberal" se destraba de la explotación tanto de las aguas profundas del Golfo de México como del tóxico gas shale (gas esquisto/lutitas)[11], que merece tratamiento especial por las series consecuencias para disponibilidad de agua en zonas adyacentes a los sitios de extracción

El siguiente cuadro 1, refleja las medidas de apertura que se le otorga a una industria petrolera subcontratada.

| **Cuadro 1** | |
|---|---|
| Gobiernos neoliberales | Apertura de la industria petrolera |
| Gobierno de Vicente Fox (2000-2006) | Privatización integral de la industria del gas. Desmantelamiento del Instituto Mexicano del Petróleo, centro estratégico de investigación científica y tecnología vinculado a petróleos mexicanos. |
| Gobierno de Felipe Calderón (2006-2012) | Se permite a las transnacionales de Estados Unidos controlar (mediante contratos la extracción de yacimientos marítimos de las principales reservas de crudo en las aguas del Golfo de México, al tiempo que se busca (en dos ocasiones 20 (mayo de 2008 y 2011) acelerar el proceso de privatización de la |

[10] "Entre las 12 principales trasnacionales menos éticas (¡supersic!) aparecen tres petroleras de EU: Halliburton, Chevron y Occidental Petroleum. Exxon Mobil (449 mil millones de dólares en ingresos; tercer lugar del ranking de las 500 trasnacionales más poderosas Fortune/CNN): su enorme derrama (750 mil barriles) en Alaska en 1989 compite con BP en el Golfo de México por el mayor daño global al ambiente" (Alfredo Jalife-Rahme, 2014).

[11] La producción de shale gas o gas natural de lutita en los Estados Unidos ha sorprendido al mundo por su rápido desarrollo y repercusión en la disminución del precio del combustible y el aumento de reservas de hidrocarburos. Este desarrollo ha crecido junto con la oferta de petróleo y de condensados de gas natural. Se estima que los Estados Unidos serían autosuficientes en petróleo y superavitarios en gas natural en menos de 30 años. El renovado impulso de los hidrocarburos no-convencionales empieza a ser visto como una revolución energética que dará nuevo dinamismo a la economía de ese país. Por su novedad, la evaluación completa de estos desarrollos confronta dificultades metodológicas, estadísticas y de conocimiento científico, tecnológico, social y económico. Las regiones de los Estados Unidos y Canadá con yacimientos de shale gas comprobados son muchas.

| | |
|---|---|
| | industria petroquímica en manos del Estado. A finales del sexenio (mayo de 2012) se calcula que el 80% de la industria petrolera y el 55% de la industria eléctrica estaban ya en manos privadas. |
| Gobierno de Peña Nieto (2012-2018). | El 20 de diciembre de 2013 se publicó en el Diario Oficial de la Federación (DOF), las reformas y adiciones constitucionales en materia energética. Asimismo, el pasado 30 de abril de 2014, el C. Presidente de la República envió al Congreso de la Unión un paquete con proyectos de Decreto que expiden, reforman, adicionan y derogan diversas disposiciones de leyes secundarias que podrá ser discutido y aprobado en un periodo extraordinario de sesiones en junio del presente año. En materia de hidrocarburos, se modificaron los artículos 27 y 28 constitucionales para permitir la participación de los sectores público y privado en las actividades de la industria energética. Esta iniciativa propone un nuevo esquema sin precedentes en el país, el cual busca trascender en todos los ámbitos. |
| Fuente: elaboración propia. | |

En el gobierno de Peña Nieto con la reforma energética, ya aprobada se pone en práctica la acumulación por despojo que se hace posible legalmente por las reformas constitucionales y de leyes secundarias en materia energética y que correspondieron a formas de dominación política, mediante un complejo proceso de presión-negociación-cooptación, o incluso represión, a los actores del campo. Cómo se ya se explicó, la acumulación por despojo y/o desposesión, incluye la mercantilización y privatización de la tierra y la expulsión forzosa de las poblaciones campesinas; la conversión de diversas formas de derechos de propiedad -común, colectiva, Estatal, etc, y en derechos de propiedad exclusivos; la supresión del derecho a los bienes comunes-.

Cabe mencionar que una de las formas jurídicas de atentar contra la propiedad de las tierras y los territorios indígenas es la expropiación, un acto unilateral de la Administración Pública, Federal o Estatal, cuyo fin es privar a los propietarios, privados o sociales, del uso, goce, disfrute y disposición de sus bienes “por causa de utilidad pública”.

La figura no es nueva; concebida durante la época cardenista (1934-19440) para fortalecer el proyecto nacional, ahora sirve para fomentar el lucro individual en detrimento del bien común y de la propiedad social. La expropiación ha sido usada por el Estado mexicano para llevar a cabo grandes obras públicas que luego se entregan a los particulares para que las usufructúen, entre ellas las presas hidroeléctricas (López, F 2014).

Respecto al despojo de tierras privadas, sociales e incluso públicas en favor de las empresas extranjeras que llegarán al país a explotar el petróleo, está incluido en la ley de hidrocarburos (artículo 33)[12] y se amplía en la ley de órganos reguladores coordinados en materia energética. Se establece que los contratos para exploración y extracción de hidrocarburos, para tender ductos, además de construir la infraestructura respectiva, se otorgarán conjuntamente con la respectiva declaración de utilidad pública de los predios en cuestión[13].

Cabe citar el artículo de López, B (2014) que refleja en forma similar lo postulado aquí, la reflexión de López Bárcenas, nos explica que las reformas legales que se están consumando en el Congreso de la Unión para transformar profundamente el régimen de extracción del petróleo y el gas, así como la generación de energía eléctrica, representan una segunda desamortización de las tierras y los recursos naturales, similar a la que se vivió en el país en el siglo XIX, pero esta reforma energética va más allá. De acuerdo con el Diccionario de la Real Academia de la Lengua Española, desamortizar es situar en estado de venta los bienes de manos muertas, mediante disposiciones legales.

El agravante de esta reforma de ley, es que los recursos, no están en manos muertas, es decir están improductivas, sino que estos recursos, han servido para generar bienestar a los mexicanos. El despojo de tierras se aplicará con toda seguridad a las comunidades agrarias, que son las que se van afectar más, pues son las que poseen en propiedad la mayor parte del

[12] Diario Oficial de la Federación (2014). Ley de Hidrocarburos se reforman diversas disposiciones de la Ley de Inversión Extranjera.
[13] Reforma Energética Resumen del proyecto de decreto que expide las leyes secundarias en materia de hidrocarburos. El presente resumen considera las iniciativas de leyes secundaria en materia energética, enviadas por el Ejecutivo Federal el pasado 30 de abril del presente año, al Congreso de la Unión, por lo que está sujeto a cambios que serán aprobados durante el mes de junio próximo

territorio mexicano, lo mismo que los territorios de los pueblos indígenas[14], que son bajo los cuales se encuentran los bienes codiciados por el capital. Con las reformas se abre el camino para un uso discrecional de expropiar y de imponer modalidades a la propiedad; la diferencia es que estas medidas privatizadoras no están orientadas a favorecer el fortalecimiento de la nación y el cuidado de sus bienes, para que apuntalaran el bienestar de los mexicanos, ahora se usarán en beneficio de los particulares.

López, Bárcenas (2014), recalca que las medidas colaterales a la Ley energética; en cuanto a expropiaciones, no restringirán la acción del capital, sino que este capital, se utilizará para despojar a los campesinos y pueblos indígenas de sus propiedades, en nombre de la nación, aunque todos sabemos que es para favorecer a los dueños del capital trasnacional.

La Ley energética se pondrá en práctica a través de las comisiones de la reforma Nacional de Hidrocarburos y Reguladora de Energía, que son los órganos reguladores del sector energético, tendrán además la facultad, según el mismo artículo 33, de ‘‘promover los actos jurídicos que se requieran para hacer efectiva, la declaratoria de utilidad pública, siendo siempre estas actividades de interés social y de orden público, por lo que tendrán preferencia sobre cualquier otra que implique el aprovechamiento de la superficie del subsuelo de los terrenos, afectos a éstas. Estos órganos reguladores facilitarán el trabajo a las empresas extranjeras. ‘‘Ellas no tendrán que negociar nada, desde el Estado mexicano se harán las gestiones para que puedan disponer de los predios que requieran para hacer los negocios con el petróleo o la electricidad’’.

Este artículo 33 ‘‘abre la puerta a la expropiación de terrenos por supuesta utilidad pública, a afectaciones, incluso a reservas de la biosfera, esta disposición va más allá de la reforma energética aprobada en diciembre de 2014”.

En síntesis, la reforma de la ley de hidrocarburos y sus leyes secundarias permiten que empresas privadas, nacionales o extranjeras, inviertan en México en la exploración y explotación de hidrocarburos: petróleo, gas y sus derivados. Desde la expropiación petrolera

[14] La Reforma a la Ley Agraria de 1992 es un ejemplo de la institucionalización de un cambio de este tipo. La intención de la reforma fue liberalizar el mercado de tierras con el objetivo de fomentar la penetración de relaciones capitalistas de producción. El ejidatario, ahora “liberado” de la tierra, se ve convertido en mano de obra barata.

de 1938, estas actividades eran exclusivas del Estado. La manera en la que las empresas privadas podrán participar en la exploración y explotación de hidrocarburos será a través de la celebración de contratos con el Estado. Estos contratos podrán ser de licencia, de servicios y de utilidad o producción compartida, y serán asignados a través de licitaciones por la Comisión Nacional de Hidrocarburos (CNH), uno de los dos órganos reguladores del sector.

La misma Ley de Hidrocarburos contempla la posibilidad de que el área contractual otorgada a un particular abarque terrenos en poder de un propietario. En ese caso, para poder iniciar sus actividades, el contratista tendrá que llegar a un acuerdo con el dueño de la tierra, ya sea de compraventa o para permitir el uso por medio de las figuras de servidumbre legal, ocupación temporal o afectación superficial.

La ley también abre la puerta a la explotación de gas de esquisto o shale, que se obtiene mediante una práctica conocida como fractura hidráulica o *fracking*. Esto consiste en perforar la tierra e introducir agua y químicos a presión para sacar el hidrocarburo.

Sin embargo, la propia Alicia Bárcena Ibarra, Secretaria General de la Comisión Económica para América Latina y el Caribe (Cepal)[15], propuso que México no sólo mire el caso de Noruega para lograr mayor independencia en la explotación de su petróleo, sino también considere los modelos de Bolivia y Ecuador, integrantes de la Alianza Bolivariana para los Pueblos de Nuestra América. Vale la pena ver con detalle las estrategias de Bolivia y Ecuador, que incluso cambiaron sus constituciones, renegociaron sus contratos con las empresas extranjeras y lograron convenios mucho más favorables a sus sociedades. En el caso de Noruega, se mantiene un fuerte pacto social. Eso es lo que debemos hacer, lo que nos puede dar la esperanza de que los recursos naturales van a estar al servicio de nuestra sociedad.

[15]Petrich, B (2014).

Cabe citar el caso de Bolivia (Petrich, B 2014), que se antojaría como un modelo a seguir por la forma como renegoció sus concesiones y contratos con las empresas trasnacionales en las minas y el gas. El gobierno de Bolivia del Presidente Evo Morales, se aplicaron, dos procedimientos. En términos de la propiedad del gas, y petróleo en menor medida, bajo tierra o en el ducto, se nacionalizó todo. Ninguna empresa particular puede inscribir los recursos que encontró en subsuelo en la bolsa de valores como propios. Para las instalaciones y la maquinaria se firman contratos de servicios. En exploración, las empresas buscan gas y petróleo y si encuentran, el recurso, éste pertenece al Estado. El gobierno, decide a quién y en cuánto se vende. Por la maquinaria, la tecnología y la mano de obra, se paga lo invertido y remuneramos con un porcentaje de ganancia entre 10 y 15 por ciento de la renta, el gobierno se queda con el resto. Como se ha visto, el caso de México va en sentido contrario, hacia la privatización y entrega a empresas extranjeras.

El resultado económico de estas nacionalizaciones de gas, hace que Bolivia, abandone su ancestral sitio entre los países más pobres de Sudamérica. Ahora, con el proceso de una política nacionalizadora de hidrocarburos y minas, Bolivia se sitúa entre las tres economías de mayor crecimiento en la región. El año próximo se espera un crecimiento arriba de 5 por ciento, éste crecimiento, está sustentado en su política de renacionalización de sus recursos naturales, principalmente gas y minería.

En el caso de México, desde hace casi 30 años, el crecimiento promedio anual muestra un declive pronunciado que no sobrepasa el 2.3 por ciento durante más de veinte años, incluso de los países latinoamericanos, México es que el menos ha crecido[16]. Si esto le sumamos que en los últimos reportes oficiales preliminares del organismo subsidiario más importante de la empresa productiva de Estado, Pemex Exploración y Producción (PEP), revelan que en enero de 2015 la producción de crudo continuó con su desplome y ahora se ubica en un promedio diario de 2 millones 235 mil barriles por día, nivel similar al que tenía Petróleos Mexicanos

[16] Conviene tener presente que en junio pasado el Banco Mundial (BM), en su informe *Perspectivas económicas mundiales,* pronosticó que el crecimiento de México no rebasaría 2.3 por ciento. Un mes después, en julio el Fondo Monetario Internacional (FMI) también modificó a la baja su previsión de desarrollo para nuestro país y lo disminuyó a 2.4 por ciento frente al 3 por ciento calculado en el mes de abril. Y apenas a inicios de agosto, la Comisión Económica para América Latina y el Caribe (Cepal) determinó recortar de 3.0 a 2.5 por ciento su pronóstico de crecimiento de la economía mexicana para este 2014. Los pronósticos para 2015 de estos organismos no rebasan 3.5 por ciento.

(Pemex) hace 35 años. El volumen de 2 millones 235 mil barriles diarios extraídos en enero de 2015 se ubica en niveles de 1980-1981 y en términos reales podría incluso ser menor, porque la producción reportada es antes de mermas, movimiento de inventarios, traspasos y sustracción ilícita o robo del hidrocarburo.

Este desplome de la producción de Petróleo se ve acompañado de un recorte presupuestal anunciado el 30 de enero de 2015 por la Secretaría de Hacienda y Crédito Público (SHCP) a la petrolera mexicana (PEMEX) por 62 mil millones de pesos[17]. La caída en la producción, la baja en las cotizaciones del crudo[18] y el recorte al gasto, tendrá implicaciones no sólo para la hacienda pública, sino para México en su conjunto. ¡El gobierno de Peña Nieto piensa revertir esta crisis con la llegada de inversiones en el sector energético a partir de las reformas implementadas, se logrará, sustentar un crecimiento económico incluyente para todos los mexicanos, aquí se ha sostenido que no!

Las interrogantes, son ¿Por qué México no crece? ¿Por qué la economía no asciende lo suficiente para satisfacer las necesidades de empleo y de bienestar de la mayoría de los mexicanos?

En el informe publicado en marzo de 2014 y realizado en conjunto por el Instituto Global McKinsey y la oficina de McKinsey en México (2014): La historia de dos México´s: el crecimiento y la prosperidad en una economía de dos velocidades*,* se analiza la problemática del crecimiento económico de nuestro país: hay dos México´s, uno donde florece una economía moderna de alto crecimiento y el otro donde está instalada la economía tradicional de bajo rendimiento. Estos dos México´s, se están moviendo en direcciones contrarias: mientras que en el sector moderno hay crecimiento y se puede competir a nivel internacional,

[17]"El gobierno federal reconoció el 31 de enero de 2015, la necesidad de recurrir a un recorte en el gasto público por un monto de 124 mil millones de pesos, equivalente a 0.7 por ciento del producto interno bruto (PIB). La medida fue calificada por el secretario de Hacienda, Luis Videgaray Caso, como de carácter preventivo en reconocimiento a un cambio en el entorno financiero internacional y a la caída en los precios del petróleo" (González, R 2015).

[18] La mezcla de petróleo mexicano de exportación se cotizo en 91 dólares en enero de 2014, ya en los primeros de días febrero de 2015, el precio se desplomo a 40 dólares por barril, más del 100% de caída, en estos primeros meses de año. El precio de la mezcla de petróleo mexicano de exportación, es la principal fuente de financiamiento del gasto público y se muestra una tendencia a su disminución que se ha mantenido.

en el tradicional con empresas pequeñas y medianas, algunas a menudo informales, la productividad se hunde.

**Conclusiones.**

Se ha dicho que la acumulación por desposesión y/o despojo no puede implementarse sin el apoyo irrestricto del Estado y que éste ha sido un actor central en los cuatro aspectos que cubre la acumulación por desposesión (privatización y mercantilización, la financiarización, la gestión y manipulación de la crisis y redistribuciones de la crisis). Siendo el Estado, empleador de la violencia y hacedor de la legalidad, es evidente que todo proceso económico que implique manejo de recursos económicos y/o activos financieros pasa por su tamiz para cubrir el despojo jurídicamente, pues hay que recordar que el Estado es un poder de clase que se expresa en flexibilizar las leyes (desregulación) para que las distintas denominaciones del capital (minero) se adueñen de los recursos productivos y financieros de sus territorios y, así permitir que el capital aproveche las condiciones desiguales en la economía espacial en términos de distintas dotaciones de recursos diferenciales en el ámbito nacional, regional y local.

Al cuestionamiento de la actividad de las empresas transnacionales en la explotación del patrimonio natural (recursos mineros, petroleros, turísticos, agrícolas, etc. ), habría que tomar en cuenta: por un lado, el daño ambiental que la actividad extractiva suele provocar en el entorno de sus operaciones, cuyas secuelas son difíciles de mitigar a corto y mediano plazo, además de afectar a las poblaciones cercanas y por otro lado también, los nulos o pocos aportes de dichas transnacionales a los ingresos fiscales, vía pago de impuestos y otras regalías. Hay que plantearse, la necesidad de que las empresas paguen lo que corresponde por el derecho de extraer recursos naturales no renovables, teniendo en cuenta que existen abundantes recursos y buenas condiciones físicas para la explotación y/o su extracción, lo que abarata los costos de las compañías.

En este sentido, los procesos de sobreexplotación del entorno ambiental, castigan aún más a aquellos recursos no renovables como gas natural, petróleo, metales y piedras preciosas, que han configurado la base fundamental de las actividades extractivas generadoras de renta en enclaves económicos.

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## 7.3 G3. Análisis de la eficiencia de la industria europea de distribución de gas - Pablo Coto-Millán, Lucía Inglada-Pérez, Pedro Casares-Hontañón, Vicenter Inglada

### Análisis de la eficiencia de la industria europea de distribución de gas.

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ABSTRACT

There is a general consensus that energy plays an essential role in the welfare and sustainable economic development of today's society. This article studies the efficiency of European companies in the pipeline gas distribution sector in 2016. For this purpose, the methodology called Data Envelopment Analysis (DEA) is applied, which allows the estimation of global, pure and scale efficiency of each company. The data sample corresponds to 210 European gas distribution companies belonging to 16 countries in 2016. The results obtained show that the size of the company has a positive effect on its degree of technical efficiency. They also suggest that the regulatory context existing in the country where they perform their activity plays a significant role in the efficiency of the gas distribution sector.

Palabras clave: energía, DEA, eficiencia técnica, Europa
JEL codes: L11, L23, L95

Keywords: energy, DEA, technical efficiency, Europe
JEL codes: L11, L23, L95

**AREA CIENTÍFICA**

6. Economía, energía y medio ambiente: los desafíos internacionales

## 1. Introducción

Existe un amplio consenso en que el factor energético constituye un input fundamental para la economía y sociedad actual (Coto-Millán et al. (2018). Para las empresas de cualquier sector representa un alto porcentaje de sus costes y para las economías doméstica una parte significativa de sus gastos (Bai-Chen et al., 2018).

El objetivo básico de este trabajo es analizar la eficiencia técnica en las empresas europeas de distribución de gas en 2016. Las empresas de distribución se caracterizan por la existencia de una elevada diferenciación en su tamaño. Por todo ello, no solo se estudia su nivel de eficiencia sino también se descompone la eficiencia de cada uno de ellos en sus dos componentes, asociadas, respectivamente, a la escala y la puramente técnica. En la eficiencia de escala intervendría decisivamente el tamaño de la empresa. Asimismo, se estudian los efectos del tamaño de la empresa n del contexto regulatorio del país donde desarrollan su actividad sobre el nivel de eficiencia de cada empresa. El estudio se lleva a cabo sobre 210 empresas pertenecientes a 16 países europeos, utilizando una metodología de análisis no paramétrico.

La metodología empleada en esta investigación se compone de dos etapas (Pastor, 2002). En la primera etapa estimamos los niveles de eficiencia técnica global, pura y de escala para la muestra seleccionada de empresas europeas de distribución de gas seleccionada. A continuación, mediante el análisis de regresión, estimamos el efecto de factores externos como el tamaño de la empresa y el contexto regulatorio, sobre los índices de eficiencia obtenidos. La herramienta metodológica empleada es el denominado Análisis Envolvente de Datos (DEA), una técnica de programación lineal no paramétrica que es adecuada para estimar la eficiencia y rendimientos de escala mediante la construcción de la frontera más eficiente. Esta metodología presenta, entre otras, la ventaja de su flexibilidad, al no imponer forma funcional alguna para la frontera tecnológica, que es construida a partir de las prácticas más eficientes y sus combinaciones lineales.

Dado su interés, no es extraño que en la literatura sobre eficiencia y se reconozcan numerosos trabajos que analizan la eficiencia técnica de la industria energética (ver las revisiones de la literatura específica sobre este tema realizadas por Mardani, et al., 2017; y Sueyoshi et al., 2017). Sin embargo, no existe, en nuestro conocimiento, un estudio para el caso europeo que considere una muestra tan amplia de empresas de distribución del gas y de países como se realiza en esta investigación.

Con estos objetivos, la estructura de esta investigación es la siguiente. En la sección segunda se revisa la metodología utilizada para el cálculo de los índices de eficiencia técnica y de escala. En la sección tercera se describen y analizan los datos utilizados. A continuación, en la sección cuarta se discuten los resultados obtenidos, y por último, en la sección quinta se exponen las principales conclusiones.

## 2. Metodología

### 2.1. Análisis Envolvente de Datos (DEA)

Se considera una empresa que emplea K factores productivos: $\overline{X} = (X_1, X_2, \ldots X_k)$ que están disponibles a unos precios fijos, para producir un producto Y, que se puede vender a un precio fijo. Desde la perspectiva de la eficiencia, la característica básica la función de producción radica en que proporciona la máxima cantidad de producto que es posible obtener para cada vector de cantidades aplicadas de los factores productivos, bajo ciertas condiciones impuestas por la tecnología. Por tanto, describe un límite o frontera y así en la literatura económica esta función es denominada función frontera ya que caracteriza el comportamiento optimizador de un productor eficiente y por tanto, marca los límites de los posibles valores de su respectiva variable dependiente. Las medidas de eficiencia de las unidades investigadas se obtienen comparando los valores observados para cada unidad productiva con el óptimo definido por la frontera estimada.

La hipótesis de rendimientos constantes de escala es un supuesto altamente restrictivo en la medida de la eficiencia técnica. En este sentido, Forsund y Hjalmarsson (1979) consideran la alternativa de rendimientos variables e introducen el concepto de eficiencia de escala. Un proceso de producción puede basarse en la hipótesis de rendimientos constantes de escala (CRS), aunque en la mayoría de las situaciones es más apropiado suponer una tecnología con rendimientos variables de escala (VRS). Cuando existen grandes disparidades en el tamaño de las unidades de producción, hecho que sucede en los aeropuertos españoles, sería conveniente comparar cada unidad con otras similares en escala de producción ya que la diferencia de magnitud de la ineficiencia entre unidades podría ser debida a la escala.

Asimismo, el índice de eficiencia técnica admite dos especificaciones dependiendo de que se tome como referencia el nivel de producción o los factores productivos. En el primer modelo, orientado hacia el output, se mide la proporción en que se puede incrementar el nivel de producción con las cantidades de factores empleadas mientras que, en el segundo modelo, orientado hacia el input, se mide la proporción en que se pueden reducir los factores productivos para seguir produciendo la misma cantidad de output. En una tecnología de rendimientos constantes de escala, las dos versiones del índice coincidirían. En el caso de los servicios públicos, en general, el output está relacionado a la demanda existente que es una variable, en gran medida, exógena a la empresa, mientras que el ahorro de costes es uno de los objetivos relevantes de la empresa. Por ello, en estos casos se dan las condiciones idóneas para desarrollar un modelo de proyección orientado al input y este será el modelo adoptado en esta investigación.

La técnica denominada Análisis Envolvente de Datos (DEA) parte de Farrel (1957) que propone construir lo que denomina isocuanta envolvente a partir de

los ratios inputs-output observados, con datos de sección cruzada[1]. Este método de cálculo ha sido desarrollado con posterioridad por Charnes, Cooper y Rhodes (1978). Esta metodología tiene la ventaja de permitir relajar supuestos como el de rendimientos constantes y contemplar casos más generales como el de las tecnologías multiproducto. Mediante esta técnica se construye una frontera de producción de referencia mediante métodos de programación matemática a partir de unidades productivas eficientes y de combinaciones lineales de las mismas. Esta frontera poligonal lineal no paramétrica representaría el proceso óptimo en la transformación de un conjunto de inputs en los outputs finales. Las medidas de la eficiencia son las distancias que separan a cada empresa de la frontera. Una descripción completa de esta metodología DEA se realiza en Cooper et al. (2000), Thanassoulis (2001) y Salazar (1999). Este tipo de metodología basada en la identificación de fronteras no paramétricas ha sido frecuentemente utilizado en la literatura económica, fundamentalmente para el sector bancario, agrario, hospitales y transporte ferroviario y aéreo.

A continuación, se presenta el ejercicio de programación lineal correspondiente a los modelos DEA orientados al input y con rendimientos contantes y variables de escala que es el utilizado en esta investigación. En el caso de *n empresas*, la magnitud de la eficiencia técnica ($ET_j$) de cada empresa *j* bajo rendimientos constantes de escala (CRS) y un modelo DEA orientado hacia el input, puede estimarse resolviendo el siguiente problema de programación lineal (Coelli, 1996):

$$ET_j = \underset{\theta_j^{CRS}\lambda}{Min}\ \theta_j^{CRS}\ sujeto\ a: Y_j \le Y\lambda; \theta_j^{CRS} X_j \ge X\lambda; \lambda \ge 0 \qquad (1)$$

Donde *X* e *Y* son respectivamente los vectores input y output, $\theta_j^{CVS}$ es la eficiencia técnica de la empresa *j*, suponiendo rendimientos constantes de escala, y $\lambda$ es un vector de pesos o ponderaciones de dimensión *n* x *1*. Estas ponderaciones no pueden ser negativas y miden la contribución de las unidades seleccionadas eficientes a la definición de un punto de referencia para la empresa ineficiente *j*. En general, $0 \le \theta_j^{CVS} \le 1$, donde $\theta_j^{CRS} = 1$ si la empresa está produciendo sobre la frontera de producción y por tanto es técnicamente eficiente. Cuando $\theta_j^{CRS} < 1$, la empresa es técnicamente ineficiente. Para obtener la eficiencia técnica $\theta_j^{VRS}$ bajo rendimientos variables de escala (VRS) se añade la restricción de convexidad $\sum_{j=1}^{n} \lambda_j = 1$ a la ecuación (1).

### 2.2. Análisis de regresión

[1] Esto es, con datos de de cada unidad (en este caso empresas) para un año determinado.

En la segunda etapa estimamos el efecto de nuestras variables explicativas externas -tamaño de la empresa y nivel regulatorio- sobre los índices de eficiencia mediante una regresión truncada estimada por el método de máxima verosimilitud. Para ello utilizamos el modelo Tobit (Tobin, 1958) debido a que la variable dependiente está acotada por cero y uno. El modelo que define la relación entre la eficiencia productiva y las variables ambientales explicativas es la siguiente:

$$y_i = \beta_0 + \beta_1 tam_i + \beta_2 regu_i + \varepsilon_i \qquad (2)$$

Em este modelo la eficiencia técnica es la variable dependiente. Las variables explicativas externas son: el tamaño de la empresa, medido por el volumen de sus ventas y el contexto regulatorio existente en el país, medido por los índices de regulación en la industria del gas para los países de la OCDE (Koske et al., 2015).

### 3. Análisis de los datos

La base de datos utilizada para la obtención de la información sobre las empresas del sector de distribución de gas por tubería ha sido AMADEUS y la muestra está integrada por 210 empresas dentro del código de actividad 522 (Distribución por tubería de combustibles gaseosos) de la CNAE 2009 (Clasificación Nacional de Actividades Económicas) revisado.

La selección de las variables utilizadas como inputs y outputs de la función de producción está basada en la literatura existente y en la disponibilidad de datos y coincide con la adoptada en diferentes trabajos como los Coto et al. (2018) y donde se explica con detalle el proceso de selección y las características de las variables utilizadas. El output utilizado es el valor añadido. Los inputs considerados están asociados con los distintos tipos de gasto, es decir, coste de personal medido por el número de trabajadores, capital medido por el inmovilizado neto y consumos intermedios. Asimismo, para el análisis de regresión de la segunda etapa del proceso metodológico se han utilizado como proxy de la dimensión de la empresa al volumen de ventas de cada empresa obtenido de la misma base de datos, así como los índices de regulación en la industria del gas para los países de la OCDE (Koske et al., 2015.).

**Tabla 1. Magnitudes de los principales estadísticos de inputs y outputs**

| | Variables | Mínimo | Máximo | Media | Desv. típica |
|---|---|---|---|---|---|
| **Output** | Valor añadido (miles de euros) | 152,2 | 987102 | 33701,6 | 106644.4 |
| **Inputs** | Inmovilizado (milles de Euros) | 29,3 | 4527446,2 | 151053,3 | 458619, 5 |
| | Número de trabajadores | 5 | 4309 | 355,2 | 733, 9 |
| | Consumos intermedios (miles de Euros) | 1,1 | 566369,2 | 20790,2 | 65108,4 |

Fuente: Elaboración propia.

En la tabla 1 se muestran las magnitudes de los principales estadísticos correspondientes a las variables elegidas como inputs y outputs. Se comprueba que para todas las variables existe una gran disparidad entre sus valores máximo y mínimo. Este resultado muestra la existencia de una elevada concentración de las empresas de este sector.

## 4. Análisis de los resultados

### 4.1. Índices de eficiencia

**Tabla 2. Ranking de países según sus magnitudes de eficiencia técnica pura**

| | Eficiencia técnica global | **Eficiencia técnica pura** | Eficiencia de escala |
|---|---|---|---|
| Austria | 0,400 | 0,909 | 0,426 |
| Suiza | 0,159 | 0,791 | 0,201 |
| España | 0,417 | 0,659 | 0,665 |
| República Checa | 0,416 | 0,557 | 0,805 |
| Suecia | 0,209 | 0,506 | 0,652 |
| Polonia | 0,035 | 0,447 | 0,469 |
| Bulgaria | 0,039 | 0,385 | 0,234 |
| Francia | 0,311 | 0,381 | 0,599 |
| Hungría | 0,068 | 0,381 | 0,557 |
| Italia | 0,113 | 0,363 | 0,417 |
| Portugal | 0,083 | 0,328 | 0,355 |
| Rumania | 0,114 | 0,274 | 0,484 |
| Alemania | 0,095 | 0,182 | 0,683 |
| Eslovenia | 0,083 | 0,164 | 0,629 |
| Luxemburgo | 0,133 | 0,134 | 0,99 |
| Ucrania | 0,059 | 0,100 | 0,656 |

Fuente: Elaboración propia

En la tabla 2 se muestran las magnitudes de los índices de eficiencia global, pura y de escala para los 20 países que forman parte de la muestra obtenidos como media de los valores de sus empresas. Cabe destacar que, en relación con la eficiencia técnica global, los países con un mayor valor de su eficiencia técnica pura son: Austria (0,909); Suiza (0,791); España (0,659); República Checa (0,557) y Suecia (0,506). Por el contrario, los de menor eficiencia técnica pura son Rumania (0,274); Alemania (0,182); Eslovenia (0,164); Luxemburgo (0,134) y Ucrania (0,100).

### 4.2. Resultados del análisis de regresión

**Tabla 3. Resultados de la estimación del modelo de regresión Tobit**

| **Factores explicativos** | **Modelo 1: Efecto marginal (t-statistic)** | **Modelo 2: Efecto marginal (t-statistic)** |
|---|---|---|

| | | |
|---|---|---|
| Dimensión | $4.52e^{-07}$*** (3,17) | $4.20e^{-07}$ (2,91) |
| Contexto regulatorio (Régimen de Mercado) | -0,0727** (-2,87) | --------- |
| Contexto regulatorio (Integración vertical) | ---------- | 0,0228 (1,46) |

Notas: ***, **, and *: Significativamente estadística al 1%, 5% and 10%, respectivamente.
Fuente: Elaboración propia

La tabla 3 muestra los resultados obtenidos en la estimación del modelo de regresión Tobit correspondiente a la segunda etapa del proceso metodológico. En los dos tipos de modelos el tamaño de la empresa es significativo con un coeficiente positivo. Esto significaría que las empresas de mayor dimensión poseen un mayor nivel de eficiencia que las de menor tamaño. Asimismo, los resultados obtenidos sugieren que el contexto regulatorio del país donde operan tiene un impacto significativo sobre sus niveles de eficiencia.

## 5. Conclusiones

En este trabajo, utilizando la metodología DEA orientada al input, se analiza el comportamiento de los distintos tipos de eficiencia productiva en 210 empresas europeas de distribución del gas por tubería en 2016 correspondientes a veinte países. Asimismo, aplicando un modelo de regresión Tobit se estudia si el tamaño de la empresa y el contexto regulatorio tienen un efecto significativo sobre la eficiencia técnica de la industria europea de distribución de gas.

A partir del análisis de los resultados obtenidos se concluye que la dimensión de la empresa tiene un efecto positivo y estadísticamente significativo sobre la eficiencia técnica operativa de las empresas de distribución del gas, Asimismo, el nivel de eficiencia es modulado por el contexto regulatorio en relación con el nivel de integración vertical y el régimen de mercado existente en el país donde opera.

Dada la importancia del factor energético en el bienestar social, el medio ambiente y la actividad económica, los resultados obtenidos adquieren un carácter sumamente relevante para la consecución de un desarrollo económico sostenible. Particularmente, su interés se extiende a todos los agentes involucrados con la industria gasística, incluyendo a reguladores y gestores de las empresas. En este sentido sería recomendable tener en cuenta las conclusiones surgidas de esta investigación para el diseño de una óptima política regulatoria.

La investigación futura debería estar encaminada a la consideración en el modelo de otros factores específicos de la empresa, así como de su entorno económico, determinando si su presencia modula el nivel de eficiencia productiva del sector. Otra posible ampliación de esta investigación consiste en

la estimación de la variación de la productividad y del cambio tecnológico de esta industria durante un periodo de tiempo que abarque la crisis económica mundial y los cambios regulatorios producidos. También sería interesante ampliar esta investigación con el análisis de los cambios producidos en los resultados financieros de las empresas europeas de este sector durante el periodo seleccionado.

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